Nurserymen's Meeting
Dryden
June 15-19, 1987

Ministry of
Natural
Resources

89-03767/

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Printed in Ontario, Canada

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99 Wellesley Street West
Toronto, Ontario M7A 1W3
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FOREWORD

The 1987 Ontario Nurserymen's Meeting had as its theme: "Back To Basics". The interpretation of the theme was that basic communication involved information exchange at all levels of an organization and would be achieved at the meeting through the fostering of frank and informative idea exchanges both during the formal and informal sessions of the meeting.

In my opinion and observation, the objective was achieved. This could not have been accomplished without the active participation of all attendees. The success also relates heavily to the contributions of the Dryden Tree Nursery Staff - both visible and hidden.

It is my hope that continued basic information exchange flows in the months to come and does not rely on specific gatherings to stir our initiatives to exchange. To all the participants: A thank-you, for without you the successful meeting could not have been accomplished.

J.M. McIntyre
Nursery Superintendent
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LAND PREPARATION

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Introduction

The purpose of land preparation is to prepare a seedbed that is suitable for the crop to be grown. The process that will be used will be dependent on the degree of loosening and levelling required. Other factors to be considered include the amount of fertilizers and pesticides that must be incorporated.

Limitations to land preparation often develop particularily related to the weather, and the soil itself. Soil moisture is important at the time of tillage. If the soil is too wet: the mixing, flowing action is not adequate and some soils will dry hard. If the soil is too dry: extra power would be required and there will be greater wear of tillage tools.

Drainage

Drainage - both surface and subsurface can be used to provide a longer period of proper soil moisture ensuring that tillage operations can be done if needed. Proper drainage can also help to reduce soil erosion from water by removing excess gravitational water and therefore allowing soils to absorb rainfall.

Organic Matter

Organic matter (O.M.) is a very important constituent of soils. It is present primarily in the topsoil or plow layer, with very low levels in the subsoil. The organic matter in the soil comes from the breakdown of crop residues, peat, manure, and other organic materials. Also, organic matter is a source of nutrients to growing crops, and its level has important relationships to the other additions - fertilizer, pesticides, crop, etc.
It is important that the concentration of O.M. not be reduced by mixing the subsoil with the topsoil.

Soil Types

Soil types are variable within areas and even within fields. It is important to realize soil type limitation to crop production, e.g. sandy soils tend to be droughty and lower in fertility (due in part to lower O.M.). It is also important to understand the make-up of the subsoil. Limitations to normal moisture movement and root development through compacted soil layers, either man-made or natural, can be a problem, and their location is important to possible solutions.

Soil compaction could be a result of traffic on soils too wet to support the pressure. Using controlled traffic will keep compaction to planned areas. Tillage via subsoilers can be a solution to compaction layers within reach of such equipment. Natural methods of compaction correction includes-freeze-thaw, wet-dry, earthworms, and roots.

Tillage

In addition to soils being exposed to natural forces, the use of tillage equipment can be used to improve soil structure. The moldboard plow is most popular in primary tillage to lift, loosen, turn and roughen the soil surface. Other implements used for primary tillage usually include a chisel plow or an offset disk.

Often secondary tillage via a cultivator, a tandem disk, a harrow, or a packer is used to help level and firm the soil before planting. Primary tillage equipment is heavier. Secondary tillage equipment is lighter, operated faster, and used to incorporate pesticides and fertilizer, however may be used for primary tillage under conditions of shallow working depth.

The speed and depth of tillage are important to the proper operation of the equipment. Faster travel increases power requirements but equipment may not function properly when operated too slow. Equipment for primary tillage is usually operated at 5-8 km p h (3-5 mi p h) and about 15 cm deep or topsoil depth. The secondary implements are operated 6-12 km p h and up to 10 cm deep. Soil type, obstructions (such as stones), and equipment are the main factors affecting speed; equipment, drainage, and topsoil are the main factors affecting depth.

The direction of tillage may be an important factor of soil and water management related to soil erosion. Consideration to the slope gradient and length of slope in relation to the soil's ability to resist erosion is important. Tillage and cropping options should consider the possible effect on soil erosion. However across the slope tillage alone may not help soil erosion in a heavy storm event. The type of crop cover is important. Crops planted as a cover can be used to protect the soil between rows of some crops. Once established, extra savings are returned when the area does not require tillage to keep weeds down.

Plow-down crops are important in preparing the land. Crops used to protect the soil may be plowed down to provide a source of organic matter. These crops may be grasses or legumes and in some cases they may be certain non-crop weeds. Soil tilth is very important for healthy crop production and it is important that the soil remain as stable as possible following preparation. Primary tillage, while moving the most soil, is only done once, but secondary tillage is done several times.

The number of trips over a site is critical especially related to secondary tillage. Wheel traffic compaction, and the stirring, mixing action of the

tillage equipment, will break down soil aggregates. In some cases this is desirable if heavy large clods are present, but can become excessive for soil conditions. Some of the excesses in tillage are a result of tradition, however the goal is to work the soil only as much as required to provide a seedbed or rootbed for the crop. Extra trips cost money, time, and may cause considerable problems. Headland turning can not be avoided and extra compaction and tillage is unavoidable in these areas. However a healthy soil can withstand more abuse than a soil that is run-down.

Conclusion

Land preparation is required to provide the correct medium in which to grow crops but has to be done in a manner that will conserve and protect the soil from the forces of wind and water. In cases where tillage and cropping programs do not protect the land, additional protection through windbreaks and structural erosion control devices may be necessary.

STATUS AND CONTROL OF CYLINDROCLADIUM ROOT ROT IN ONTARIO PROVINCIAL TREE NURSERIES

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Abstract

The incidence, impact and control of Cylindrocladium root rot in Ontario provincial forest nurseries are reviewed. The causal organism, Cylindrocladium floridanum Sobers and Seymour, was first detected in Ontario at Midhurst nursery in 1974. By October 1986, the disease had been confirmed in eight of ten provincial nurseries. To date, 30-55% losses have been observed in black and white spruce transplants in compartments at two nurseries. Current efforts of disease management include restricting movement of infested soil and infected stock, root raking following lifting of seedlings, and chemical fumigation. The use of cover crops, benomyl dipping of transplant stock, and repeated cultivation of fallow fields as controls are being tested under field conditions in Ontario nurseries.

Introduction

Cylindrocladium floridanum Sobers and Seymour (Cf) causes an important root rot of conifers in forest nurseries (2,8,12). All conifer species grown in Ontario provincial forest nurseries are susceptible, with the possible exception of northern white cedar (Thuja Occidentalis L.)

The distribution and impact of the disease in the province appears to have increased since it was first detected in 1974. A similar situation exists in the provincial nurseries in Quebec. The fungus may cause serious losses of conifer nursery stock. Mortality of 60-90% of conifer transplants was reported for three Wisconsin nurseries (13). In Minnesota, loss of up to 80% of seedlings in a single year in one nursery were attributed to Cf (8). Monetary loss amounted to more than $40,000. This paper sumarizes the incidence, impact, and status of Cylindrocladium root rot control in Ontario provincial forest nurseries.

Incidence

Cylindrocladium floridanum was first detected in an Ontario provincial forest nursery in 1974 by the Federal Insect and Disease Survey (FIDS) Unit of the Canadian Forestry Service (9). The fungus was isolated from roots of red pine, jack pine and white spruce seedlings in five compartments at Midhurst nursery. Isolates of the fungus were confirmed at that time to be C. floridanum rather than C. scoparium.

The FIDS Unit subsequently conducted a survey in nine provincial nurseries to determine the pathogen's distribution in Ontario nurseries (10). Cf was not detected in any of the five northern nurseries surveyed (Table 1). In the four southern nurseries the incidence of Cf ranged from 4 to 20% of the compartments sampled. A total of 168 nursery compartments were checked in Ontario nurseries. Soil samples were tested for Cf using the spot plate technique (14). The fungus was recovered at a later date by FIDS from roots of white cedar collected at the Thessalon nursery (10).

Table 1. Number of compartments tested and percentage recovery of Cylindrocladium floridanum from soil or seedlings at Ontario provincial forest nurseries during surveys conducted between 1975-86.

	Survey			
	CFS-FIDS, 1975-76[a,b]		MNR-PCS, 1981-86[c]	
Nursery	no. tested	% positive	no. tested	% positive
Kemptville	23	13	20	55
Orono	28	4	12	58
Midhurst	29	14	55	55
St. Williams	25	20	32	63
Swastika	17	0	22	32
Gogama	5	0	--[d]	--
Chapleau	6	0	--	--
Thunder Bay	18	0	7	14
Dryden	17	0	25	8

a -- using spot plate technique (14)
b -- source: Myren, Gross, and Dorworth (10)
c -- majority determined using azalea leaf baiting technique with plating on selective medium (3,7); earlier method used was alfalfa baiting technique (8) with plating on malt extract agar ammended with lactic acid; a few were determined through direct isolation from conifer seedlings on the selective medium.
d -- not tested

The Pest Control Section (PCS) of the Ontario Ministry of Natural Resources (MNR) started conducting intensive surveys within individual compartments in 1981 at the nursery superintendents' request. A number of intensive surveys

were subsequently conducted between 1981-86. Soil samples were tested for Cf using the alfalfa baiting technique (8) through 1984. The azalea leaf baiting technique (3,7) was found to be a more sensitive method through comparative testing in our laboratory and by Hunter, et al. (6). This technique, therefore, replaced the alfalfa baiting method in processing of 1985 and 1986 soil samples. In this method, small portions of symptomatic azalea leaves are plated on a Cylindrocladium selective medium (11). Direct isolation from symptomatic root systems and plating on either acidified potato dextrose agar or the selective medium was also used for detection. Over the 5 year period, Cf was recovered from 78 of 173 compartments checked in seven of the ten provincial nurseries by PCS (Table 1). Cf appears to have become more widespread among and within Ontario nurseries in the past 12 years. This may be due to movement of the fungus in infested soil or infected seedlings from one compartment to another within one nursery or in stock exchange between the nurseries. The increase in recovery, however, may also be partly due to the recovery technique used. Recovery of Cf and related C. crotolariae (a root rot pathogen of peanut) is influenced by many factors, including environmental conditions at sample collection time (12,13), sampling intensity (5), and recovery technique (6). In addition, increase in Cf populations to a detectable level during the past decade within individual compartments may have occurred. The practice of using cover crops that are also good hosts for Cf is one possible way in which increases may have occurred (13). Menge and French (8) reported that cropping with oats, rye and wheat lead to an increase in Cf inoculum potential.

Impact

Little quantitative impact data for Cylindrocladium root rot in Ontario nursery stock exists. Estimates have been determined by nursery staff through visual assessment. It is not possible, however to distinguish between root rots or confirm Cf infection visually. For example, a distinct root rot problem presently attributed to Fusarium spp. and Cylindrocarpon destructans has lead to significant losses of 2+0 red pine at Midhurst nursery. Distinction between this and Cylindrocladium root rot can only be made through laboratory isolation of the fungi. Thus, distinction between different types of root rot are not made by nursery staff in assessing losses, particularly in pine compartments.

Loss estimates for transplanted black spruce due to the root rot from compartments with a confirmed Cf problem ranged form 30-55% in three compartments in 1984 at Midhurst nursery (K. Reese, pers. obs.). Loss of white spruce transplants due to Cf, however, have been low (approx. 10%) at Midhurst in the past 3 years.

Prior to 1986, observed Cylindrocladium incidence in white spruce transplants in other Ontario nurseries has been low as well. During the annual inventory at St. Williams nursery in September 1986, however, significant levels of the root rot (up to 50%) were estimated by nursery staff. PCS was requested to provide a more precise estimate of the losses anticipated due to Cf alone.

Fifteen 1.1 m^2 plots were established throughout one compartment (A20) of 1.5+1.5 white spruce at the St. Williams nursery in September 1986. Assessment was based on stand counts and results of laboratory isolation from seedlings collected from each plot. Thirteen percent of the 1360 seedlings examined were symptomatic for Cylindrocladium root rot and 9% were dead based on a visual assessment. The fungus (Cf) was recovered from 33% of the symptomatic and healthy seedlings from which isolations were made. The total number of infected seedlings in the compartment was estimated as 122,000 based on isolation data, the density obtained from stand counts, and total lineal metres of trees in the field. If mortality of the dead seedlings observed were assumed to be caused by Cf the impact would be even greater, i.e. 38% of the total seedlings in the compartment.

Mortality can also be expected to occur in infected transplant seedlings which pass nursery grading and inspection, and are shipped for planting. In a 1981 trial, McGauley determined that 21% of the mortality observed within the first 4 months of outplanting 1016 black spruce transplants was due to Cf (unpub.file rep.). These trees had passed the grading criteria for height, stem diameter, single leader and good color.

Higher rates of mortality were found in a Wisconsin study in which a grading step was apparently not included. Thies and Patton (14) reported that 41% of 500 red pine transplant seedlings died the first year following outplanting. An aditional 19% died during the second year resulting in a total mortality rate of 60% within 2 Years.

Additional impact data for Cylindrocladium root rot in Ontario nursery stock is needed. Not only would such data aid nursery staff in forecasting number of shippable stock but would also assist staff in making disease management decisions. Pest Control Section staff are conducting additional assessments in four other nurseries this year.

Disease Management

Integrated disease management measures are being taken by the provincial nurseries to control Cylindrocladium root rot. These involve chemical, cultural, and sanitation measures.

Two nurseries with serious root rot problems have used chemical fumigation to reduce the pathogen population. Three fumigants were tested by PCS in 1982 for Cylindrocladium control at Midhurst nursery. Dazomet 98% (Basamid, PCP reg. no. 15032) was determined to be more effective than methyl isothiocyanate (Vorlex liquid soil fumigant, PCP reg. no. 7701,) and metam (Vapam, PCP reg. no. 6453) at three different rates in a sandy loam soil (B. McGauley, unpub. file rep.). The optimum application rate was 354 kg/ha.

Fumigation has reduced the level of Cf in infested fields. Soil samples from seven compartments were collected and tested for Cf before and after fumigation between June and September 1985. Prior to treatment, Cf was recovered from 7-93% (mean = 41%) of 15 samples from each compartment.

Following treatment Cf was not recovered from any of 15 samples in five fields and from one sample (7%) in each of two fields (Juzwik, upub. data).

The treatment has also provided weed control into July of the season following fumigation in several fields (C. Mansfield, pers. Comm.). However, root rot problems associated with Fusarium spp. and Cylindrocarpon destructans in white and red pine seedbeds have been observed in the second year following seeding in fields that had been fumigated.

Attempts to restrict movement of infested soil and infected stock within and between nurseries are made by the provincial nurseries. An equipment rinsing station has been constructed at Midhurst nursery. Equipment used in Cf infested fields is thoroughly rinsed with water under high pressure to remove adhering soil before entering another field. A trailer mounted tank (380 L) with a portable high pressure pump was built at Midhurst for this purpose.

The degree to which nursery compartments have been cleaned of cull material following lifting of shippable stock has varied in the past 5 years due to budget constraints. Improved sanitation practices would lead to better Cylindrocladium control since infected root and shoot material in which microsclerotia would increase would be removed from the fields. Root raking devices have recently been acquired by several nurseries to improve the clean-up of fields.

Nursery staff are also attempting to manage the disease through alleviating or reducing stress to seedlings when possible. Practices such as amount of irrigation water, time of transplanting (e.g. May versus July), and planting depth of transplant stock have been considered.

Two methods reported to be effective for Cylindrocladium control in the north central states of the U.S.A. are currently being tested in Ontario. Because the Cylindrocladium problem at Midhurst is primarily with black spruce transplants, the method of dipping roots of seedlings prior to transplanting is currently under operational testing at the nursery. This practice has been used successfully in Wisconsin nurseries (1).

Cover crops have been found to alter Cf populations in nursery soils and subsequently influence the level of root rot incidence (4, 13). Experimental trials in Wisconsin nurseries found that flax and sorghum-sudan grass when used as green manure crops for 2 or more successive years in the same field lead to a reduction in Cf population (4). These species are currently being tested at Midhurst with funding from the Canada-Ontario Forest Resources Development Agreement (COFRDA). The project is administered and conducted by PCS.

Repeated cultivation of a fallow field during the summer months is also under investigation as a method for reducing Cf populations in southern Ontario nursery soils as part of the COFRDA project.

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FUMIGATION: THE NURSERY EXPERIENCE

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Abstract

This paper provides an overview of fumigation practices of forest tree nursery soil. A discussion of the objectives nursery managers may have for fumigation and possible alternative methods points to individual choice for each specific nursery. If methyl bromide is the fumigant of choice then procedures for its proper use are outlined.

Introduction

Fumigation in this paper is defined as soil sterilization. Chemicals (biocides) which when injected into the soil volatilize, and penetrate into the air and water spaces surrounding soil particles accomplish the sterilization. Generally these chemicals are nonselective in nature. A biocide is a chemical which destroys living things. The fumigation of tree seedling nursery seedbeds is often considered either a necessary evil or a savior, much depends upon your point of view. One must accept the fact that fumigation means a total sterilization of the soil system. This means a disruption of the natural order of things; which may be viewed in a positive manner -- the destruction of disease organisms, weed seeds, nematodes, and other organisms harmful to tree seedlings -- or a negative manner -- the destruction of earthworms, beneficial fungi, mycorrhizae, and other beneficial micro-organisms (bacteria) (Campagna and White, 1973). As well there are negative features imparted to seedlings by biocides. These include an undesirable shoot-root ratio, succulent tops, ineffective root systems due to poor mycorrhizae development and lack of fibrosity. These features are caused by both the growth depressing and stimulating effects of biocides (Boyd, 1971. Iyer, et. al., 1969A. Iyer, et. al., 1969B. Wojahn and Iyer, 1976. Iyer, 1971. Sutherland, 1984. Craig, 1979. Iyer, 1975.). Yet some nursery managers use the growth stimulating properties of biocides to produce stock of accelerated growth in shorter timeframes (Anon., 1970. Smith, 1963. Stoner and Koch, 1952. Kopitke, 1951.). Fumigants are also expensive, as high as $1500/acre (Thompson, 1984), and as there are many effective pre and post emergent herbicides, fumigation primarily for weed control is not justifiable. As mycorrhizae are temporarily eliminated from the soil system, seedlings which are stunted and phosphorus deficient may result. Stunting may also be the result of a nitrification lag following fumigation, due to an elevation of ammonium nitrogen and deficiency of nitrate nitrogen (Good and Carter, 1965). However given the high value of seedlings and the neccessity of reasonable assurance of success, fumigation is valuable, albeit expensive insurance. Also the many studies citing

effectiveness of disease control is overwhelming (Williams and Hanks, 1976. Mony, 1955. Hansberg and Hollis, 1959. Howe, 1965. Bloomber, 1965. Portman and Santo, 1978. Tanaka, Russell, and Linderman, 1986.).

With these factors in mind it then lies with nursery managers to decide if fumigation is right for their specific nursery or parts of their nursery. What are the objectives? What are the risks? What are the alternatives? This paper will explore these thoughts and present some possible alternatives to fumigation.

Fumigation Decision-Alternatives

Most often the major objective of fumigation is the eradication of a specific pest. Disease organisms are the most frequent target. Weed seeds are also destroyed but often as a secondary benefit (Boyd, 1971), however not all weed seeds are destroyed by fumigation. Lupine, clover, and malva are examples of resistant species. They all have very hard seed coats which are not penetrated by fumigants. In order to make an intelligent decision regarding fumigation nursery managers need to be cognicent of three major factors. 1) What is the disease history of their nursery? This includes not only types, but frequencies and durations, and what tree species are affected. In other words, what, when, how long, and to whom? 2) What is the cropping history of the ground in question? What species of tree seedlings and cover crops were produced in this area? 3) What is the drainage of the area? Is it saturated for long periods? Is it well drained? Does it dry out during hot, dry weather conditions despite irrigation? The answers to these three questions will help managers in their decision making.

A helpful method of site monitoring is the historical perspective addressed. If there has been a history of diseases and seedling losses then fumigation may be the only alternative. Another procedure which may be followed is the monitoring of known pathogenic levels in the nursery sites being considered for fumigation. Soil assays for pathogen population levels should be taken. When are the number of propogules of Pythium, or Fusarium, or Phytopthera considered high enough to warrant fumigation above all other alternatives? If there are certain redline levels at which a prudent nursery manager should fumigate given the history of the area then the decision is very simple. These levels are best determined on an individual nursery basis, due to the uniqueness of nursery conditions. It may be that at low levels, not fumigating is a good risk or at least is not mandatory. This then addresses the question of frequency. An evaluation should be made each rotation to determine at what levels are existing pathogen populations.

There are suggested alternatives if conditions warrant non fumigation. These conditions include growing tree species with particular mycorrhizae needs -- VAM (vesicular-arbuscular mycorrhizae). VAM are necessary in the production of hardwood seedlings and with certain conifer species (Thuja occidentailis). As VAM do not readily reinnoculate fumigated nursery soils

the production of cover crops which produce fibrous roots that are host for VAM is a recommended method (Kormanik, Bryan and Schultz 1980).

Many agricultural cropping schemes are built around a crop rotation and or fallow system. This applies as well in forest tree nurseries. In Canadian Forestry Service Nurseries in British Columbia a crop rotation system is based upon soil monitoring for pathogenic levels (McElroy, 1986). The production of a low risk species (those not susceptible to known pathogens i.e. white spruce in scleroderris areas) in a suspect area is another alternative. Treatment of seed is another possible alternative in non-fumigated areas, followed by fungicidal prophylatic treatments throughout the first growing season.

Irrespective of the chosen techniques -- fumigation or an alternative-- nursery managers must begin or continue to assess soil pathogen levels by assay techniques. To blindly follow a policy because it has always been done this way is sheer folly. Trials of different alternatives may yield surprising results, or may confirm current techniques. Reaffirming does not hurt, and in the long run can only be positive.

Methods

Once the decision to fumigate is made, there are further issues to be decided. Timing. When should fumigation occur? Material. What chemical should be used? System. What procedure should be implemented?

Timing. Fumigation is often accomplished in the fall prior to sowing. Spring fumigation is also used, but can be difficult to accomplish due to unfavorable and inconsistent weather conditions. Factors such as soil temperatures, soil moisture content, condition of soil organic matter, short duration between lifting and sowing, and short duration for reinvasion of mycorrhizae fungi must weigh in favor of fall fumigation (May, 1984). The usual procedure of preparation is to turn under any cover crop, green manure crop, or soil ammendment well enough in advance of fall fumigation, so that it will be in advanced stages of decomposition. This is necessary as organic matter and crop residues readily absorb fumigants. If organic matter is not properly aged or at too high a level, higher rates of fumigants will be required for the expected control. A mid-July ploughing of the cover crop followed by a late August-early September fumigation has proven to be an effective timeframe for an early October sowing. This same timeframe may be used for a spring sowing.

Material. There are a number of soil fumigants available today. Consideration must again be given to the objective (target pest), efficacy, cost, safety, and ease of application. Commonly used fumigants are Vorlox, Methyl Bromide/Chloropicrin (MBC) in 98%-2%

and 67%-33% formulations, Dazomet, and Metam-sodium. Each is effective in its own way. Cost of fumigation depends on ownership of fumigating equipment or readily available commercial applicators, as well as product cost and application rates. As mentioned earlier, costs of fumigation are around $2,500/ha. Vorlox and MBC are the most dangerous chemicals and carry an EPA Restricted Use/Danger label. Most fumigants require some type of sealant. This may be as simple as rolling the treated ground, or as complex as laying a 2-mil polyethylene tarp to entrap the gases. Dazomet is undoubtedly the easiest to apply as it requires only a water sealant.

System. When a fumigant requiring a tarp sealant is used, there are two possible methods; The alternate strip method and the continuous tarping method. Continuous tarping has several advantages over the alternative strip method. The application proceeds at a much faster rate (12 ha/day vs 2 ha/day, unpublished records, J. Herbert Stone Nursery, Central Point, OR. and J.W. Toumey Nursery, Watersmeet, MI.). A much lower possibility of contamination of freshly fumigated soil exists with the continuous tarp method than the alternate strip method, as does a lesser possibility for heavier than necessary applications. The alternative strip method requires a number of reentries into fumigated ground to complete the task -- tarp removal, second application, tarp removal, and aeration. As this requires two tarp removals, the good possibility of overlapping applications exist as does spillage of unfumigated soil onto freshly fumigated soil. Since the task takes longer to complete it also costs more to accomplish. Weather and ground conditions are not stagnant, therefore it behooves a nursery manager to complete fumigation as quickly as possible. For these reasons a prudent nursery manager would opt for the continuous tarp technique.

Application

Soil types and conditions play a critical role during fumigation. Heavy clay or compacted soils do not lend themselves well to an efficacious fumigation treatment (Maw and Kempton, 1973). In the case of MBC-33 the injected gas is unable to properly penetrate through the soil profile. Therefore soil must be properly prepared to allow for sufficient air space. Some type of cultivation, rotary harrow, roto-tiller, or discing is required. Sandy and loamy soils are ideal types for fumigation.

Soil temperatures must be above 28°C at the fumigation depth -- 15 to 20 cm. A higher temperature would be ideal. Soil moisture levels must be adequate but not too wet. Moisture content levels should be in the 5-30% range (May, 1984). A quick check is to squeeze the soil so that it forms a ball. If it retains its shape it is probably moist enough. Another rule of thumb used is the soil should be as moist as it would be for sowing. It is imperative that the moisture content be correct for the fumigant gas to defuse properly through the soil. If the soil is too wet the gas will not penetrate quickly enough and if the soil is too dry the gas will escape too quickly.

Organic matter percent and condition affect the efficiency of fumigation. In fine textured sandy soils, high in organic matter, higher rates of fumigant are needed. These rates must be determined at each nursery. Organic matter readily absorbs soil fumigants, however if the organic matter is very moist it will not absorb as much as if it were dry (May, 1984).

Once conditions are adequate, application should begin. Application rates of 390-475 kg/ha have proven to be effective in the Lake States. The usual method of application is by injection with chisels. The fumigant is injected through polyethylene tubing attached to chisels. A fumigation rig which injects the fumigant into the soil, places a plastic tarp over the treated area and seals the edges all in one operation is the most efficient and economical application technique. These are available for either alternate strip or continuous tarp methods.

Fumigant should be injected at the 15cm level. At this depth if conditions are correct, the gas will penetrate deeper. In sandy soil, the evaporating gas will slowly move to the surface. Chisels should be set 30 cm apart for best coverage in sandy soils. The fumigant should remain covered for at least 48 hours if soil temperatures are in the 33-38°C range. A longer period of coverage, up to 72 hours is necessary if the soil is colder.

After tarp removal, fumigated soils must be properly aerated. Aeration time again depends upon soil conditions and temperature. Cool moist soils will require longer aeration periods. This is common with spring fumigation. By using indicator plants it is easy to monitor the results of the aeration process. Planting a few radish plants in the aerated areas and observing their reactions is a simple and effective way to determine if it is safe to sow. Ground should be prepared for sowing as usual taking care not to penetrate below the level of fumigation, as contamination of fumigated soil may occur by mixing. A good rule of thumb is not allowing cultivation below 12.5 cm.

Conclusion

Soil fumigation is the most effective method of control of disease organisms, and nematodes. There are beneficial side effects of weed control. Sometimes a growth response is associated with fumigation. This is not totally due to pest control but has been shown to be a nitrogen response. Abrahamson (1980) explains that an immediate rise in ammonium N follows fumigation. For 50-75 days post fumigation soil nitrogen will be largely in the ammonium form. Iyer (1971) suggests a hormone-like response, and Craig (1979) suggests a release of nutrients from destroyed soil organisms as the causal agents. This growth may be beneficial or deleterious to the well being of the seedling. Because fumigation results in soil sterilization, beneficial soil fungi are also destroyed. Reinnoculation may be sporatic and uneven in seedbeds causing stunting and phosphorous deficient seedlings. As nature abhors a vacuum, reinvasion of nonbeneficial organisms may also occur.

There are alternatives to fumigation and nursery managers should consider them. Nursery soil should be monitored for pathogens prior to deciding upon a course of action. If fumigation is accepted as a practise it must be carefully and properly applied. MBC is a dangerous chemical and in the short term disrupts the soil system.

There are different methods of applying MBC. The most efficient method is the continuous tarp method. Soil should be at the proper temperature and moisture content. Fumigation must be applied at the proper depth to obtain the desired results. Use of an effective seal to contain the fumigant in the soil is mandatory with MBC and aeration of the soil to eliminate all of the fumigant before sowing is essential. The soil should be monitored for effectiveness of treatment. Exploration of other techniques weighing cost, pathogen levels, frequency, and safety must continue at each nursery.

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UNDERCUTTING AND ROOT WRENCHING IN ONTARIO: WHERE DO WE GO FROM HERE?

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Abstract

Undercutting bareroot nursery stock has been a widely accepted technique for at least 60 years. Over this time, the objectives for undercutting and the methods and equipment used to achieve these objectives have changed dramatically. Undercutting followed by wrenching or root wrenching alone has been successful in reducing top-root ratio and the occurrence of lammas growth. These techniques also show considerable promise for conditioning stock for improved survival after outplanting and conditioning stock for overwinter frozen storage. The old idea of producing seedling stock with the morphological and physiological attributes of transplants has received renewed interest and recent trials have yielded optimistic results.

The effectiveness of undercutting and root wrenching techniques in Ontario could be improved by taking the time to compare methods, evaluate success and carefully integrate improvements into operational practice.

Introduction

The nurserymen's challenge is to grow tree seedlings of the highest quality possible. Since the first provincial nursery was opened in St. Williams in 1908, we have failed to gain the desired level of control over the final physical and physiological attributes of seedlings produced.

Many improvements have been made in our nursery system over the last 80 years, but more and better tools are required to consistently produce trees of high quality. Undercutting and root wrenching are tools that offer an incredible array of benefits. However, after 60 years of research and development around the world, the full benefit of these techniques has yet to be realized in Ontario.

Mullin (1957) observed increased nursery survival of 2+2 white spruce (Picea glauca (Moench) Voss) after machine undercutting at a depth of 11.5 cm during the 2+1 year. He suggested that a moderate undercutting coupled with top pruning improved field performance of 2+2 white spruce. Post planting survival and growth of white spruce was improved by undercutting after the flush of growth (June 25), but no significant effect was observed on white pine (Pinus strobus L.) (Mullin 1966). Red pine (Pinus resinosa Ait.) also responded to repeated late season undercuttings by increased survival in the field after outplanting (Mullin and Hutchison 1979).

On the other hand, Burgar (1965) was unable to show any improvement of the top-root ratio of 2+0 jack pine (Pinus banksiana Lamb.) by undercutting at a 10 cm depth, side cutting or by combining the two treatments.

The most recent and comprehensive work on red pine in Ontario was conducted by Bunting and McLeod (1984a, 1984b, and 1984c). They found that undercutting in July and wrenching every three weeks until October produced a significant gain in root area index (Bunting and McLeod 1984b) but reduced height, oven-dry weight and stem diameter (Bunting and McLeod 1984c). The results of this series of trials also demonstrated that undercutting followed by wrenching increased survival after outplanting during drought conditions (Bunting and McLeod 1984b) and after overwinter frozen storage (Bunting and Mcleod 1984a).

Ontario has had a richer experience with undercutting and root wrenching than the written history suggests. The results of many informal trials have been incorporated into normal operations or have been lost as nursery employees responsible for those trials have retired or departed. Thus the use of undercutting and wrenching in Ontario has primarily been influenced by documented research performed elsewhere.

Current Use In Ontario

In Ontario, there are five basic objectives of undercutting and wrenching treatments,

1. Reduce top-root ratio
2. Increase root fibrosity
3. Produce seedlings with the attributes of transplants
4. Condition for outplanting
5. Condition for overwinter storage

Frequently, one or two of these objectives are pursued independant of the others and it is unlikely all the objectives could be attained using a single undercutting or wrenching prescription. Prescriptions intended to accomplish these objectives vary greatly among nurseries and have been developed using information from the readily available literature, unpublished nursery trials and personal communication.

The most prevalent use of undercutting and root wrenching is the reduction of top-root ratio by the reduction of height growth. This has been a high priority in the production of jack pine at Gogama, Chapleau, Thunder Bay, Dryden, Thessalon and Kemptville nurseries. In general, success has been achieved using repeated wrenchings which may or may not follow a single undercutting or side cutting. This repeated wrenching must be severe enough, in terms of frequency and degree of soil disturbance, to reduce height growth while mild enough to avoid unnecessary reduction of stem diameter or root mass. An additional benefit of this procedure is reduced frequency of lammas growth. Control of top-root ratio has also been achieved by undercutting and wrenching red pine at Orono nursery (Bunting and McLeod 1984c) and Kemptville nursery.

The number of years in which insufficient control over top-root ratio has been attained indicates that a more complete understanding of the process is required. The date of initiation of undercutting and the frequency and intensity of wrenching are all major factors affecting the degree of control over morphological parameters (Bacon 1979, Benson and Shepherd 1977, Bunting and McLeod 1984c, Cameron 1969, Rook 1971 and Van Dorsser and Rook 1972). The optimum initiation time, frequency and depth of undercutting and wrenching still need to be established for jack and red pine.

Modification of the root system, primarily the production of abundant, vigorous, fine roots is one of the most sought after effects of undercutting and root wrenching. A more fibrous root system is especially desirable for red pine and white spruce as large coarse roots are frequently broken during lifting or deformed during planting. Root fibrosity is difficult to quantify and therefore documentation of changes in this parameter with undercutting and root wrenching is almost absent in past Ontario studies. However, most Ontario nurserymen believe, from experience, that the relative proportion of fine roots are increased by undercutting and wrenching of jack pine, white pine and red pine. This belief has been reinforced by recent unpublished work at Midhurst nursery that revealed a large increase in number and volume of roots of 2+0 red pine after undercutting combined with manual side cutting followed by repeated root wrenching.

In other studies, root fibrosity has been shown to increase with wrenching of radiata pine (Pinus radiata) (Cameron 1969, Rook 1971, Van Dorsser and Rook 1972), Douglas fir (Pseudotsuga menziesii) (Tanaka et al 1974, Koon and O'Dell 1977), Scots pine (Pinus sylvestris) (Parviainen 1981), Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla) (Eis and Long 1972). Hardwoods undercut shortly after germination can also produce a much more branched root system than untreated stock (Riedacker 1976).

The benefits of transplanting within the nursery include reduced height, reduced top-root ratio, larger root system, larger stem diameter, more uniform shippable product and improved field performance. All white spruce and black spruce (Picea mariana (Mill.) B.S.P.) grown in northern Ontario are either greenhouse or field transplants and a large proportion of spruce production in southern Ontario also consists of transplants. Red pine and white pine are also transplanted with much success but are most frequently grown as seedling stock due to the cost of transplanting.

The possibility of producing seedlings with the morphological attributes of transplants is only now being seriously considered in Ontario, even though this concept was first suggested by Hastings (1923) almost 65 years ago. This objective has been partially achieved with red pine and white pine at Midhurst, Orono and Kemptville nurseries. The major factors limiting the success of the undercutting and wrenching treatments appear to be seedbed density, uniformity of seedling distribution and scheduling of treatments.

Olson (1930) suggested that despite the development of satisfactory undercutting devices, transplanting would continue to be the most practical means of modifying the root system until a more uniform spacing of plants could be achieved by direct seeding. Control of seedbed density and spacing is still an important consideration in planning successful undercutting or root wrenching treatments (Menzies 1980, Tinus 1981, Van Dorsser 1981).

Precision seeding techniques are now being developed for black spruce and jack pine at Swastika nursery. If successful, this technology could provide the basis for further improvements in Ontario tree seedling production.

Conditioning for outplanting and conditioning for overwinter storage are techniques which are being examined with much interest in Ontario. Undercutting and root wrenching improved outplanting performance of red pine after outplanting (Bunting and Mcleod 1984b) and outplanting after overwinter frozen storage (Bunting and Mcleod 1984a). Unpublished research conducted at Midhurst and Kemptville nurseries has demonstrated that white pine and red pine stock undercut and wrenched in the year prior to lifting had larger root regeneration potentials after lifting. Also, unpublished results of trials at Kemptville nursery have demonstrated that root wrenching of white pine and red pine may advance the date when nursery stock is ready for lifting for overwinter frozen storage by as much as one week.

Many investigations of undercutting or root wrenching are ongoing in Ontario. The experimental methods and objectives are varied but the overall goal is to produce better trees for outplanting.

Where Do We Go From Here?

Specific information on how best to achieve stock production goals using undercutting and root wrenching must be obtained for Ontario tree species. Prescriptions that specify scheduling, method and modifications to current cultural treatments are required for each species and objective. The year of treatment, timing of treatment in relation to root growth, bud flush, or leader elongation and frequency of repeated treatments are all important considerations in designing a wrenching or undercutting schedule. Also, tractor speed, blade angle, depth of blade and soil moisture must be adjusted to provide the most efficient treatment. Finally, adjustments in cultural practices such as seedbed density, fertilizer application schedules and irrigation regimes may also be required.

At present, each nursery is developing undercutting or root wrenching techniques which meet its immediate short term needs. This approach has produced interesting and biologically significant results but has done little to improve general cultural practices across the province.

I suggest a program of planned development (Fig. 1) in which independant nursery trials would directly contribute to the collective objectives of the provincial nursery system.

The first task in this process is to fully evaluate the stock now being produced and decide on achievable targets. These targets could be in terms of morphological quality such as desired height diameter ratio, top-root ratio, mean heights and mean diameter or physiological quality such as desired root regeneration potential for specific stock types.

The second task is to use the best information available to design undercutting and root wrenching treatments which will help us reach as many targets as possible. The available scientific literature on undercutting and root wrenching has been summarized and will be available soon (Racey and Racey, in progress). However, the collective wisdom of the growers is also required to invent original, effective yet practical prescriptions which can be evaluated in well designed nursery trials.

These statistically sound nursery trials are critical in evaluating the success of proposed cultural practices and should include assessment of field outplantings. However, the most important single factor is communication. Specific, concise documentation of the findings of nursery trials and the subsequent distribution of the documentation must be completed. This is the manner in which improvements to our nursery system can be shared, so that larger advances can be made.

Conclusion

Ontario nurserymen must develop a co-ordinated approach to undercutting and root wrenching. The success attained elsewhere in the world has largely eluded the Ontario nursery system. Now is the time to deliberately develop an undercutting and root wrenching program to improve bareroot stock production in Ontario.

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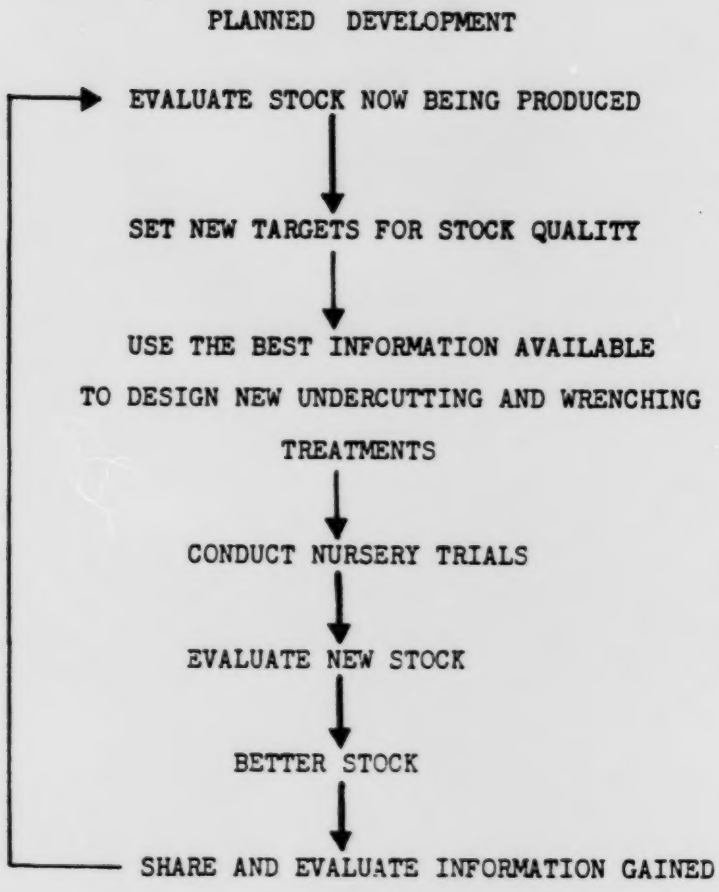

Figure 1. A general sequence for the planned development of undercutting and root wrenching techniques in Ontario.

WINDBREAKS AND CROP PROTECTION

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Abstract

Yield response of corn (Zea maize L.) and soybeans [Glycine max (L.) Merr.] to windbreak protection were studied in the field over a 4-year period from 1980 to 1983. Corn yield comparisons were obtained on both the windward and the leeward side of the windbreaks. At the start of the trials the windbreaks were 15-year-old evergreens with an approximate effective height of 6 metres.

With corn, yield increases of approximately 10% were obtained out to a distance of 10 times the height of the windbreak, on the leeward side. On the windward side an 8% yield increase was obtained out to a distance of 4 times the height of the windbreak. Soybean yield increases of 20% were obtained out to a distance of 9 times the windbreak height on the leeward side.

From a visual examination, yield differences in the field are often difficult, if not impossible to detect. Unfortunately, most people see only the actual areas taken out of production to plant the windbreak, plus the relatively small yield reductions that often results next to the trees but fail to detect the yield increases.

Historical Background

Pioneer clearing of our virgin forests in Ontario began some two and one-half centuries ago. For nearly 200 years after the coming of the early European settlers, livestock-based farming systems dominated. Crop rotations that involved a high proporation of grass and legumes were a must on virtually all farms. Nitrogen had to be produced 'on the farm' since chemical sources were at best scarce, consisting probably of saltpeter from Chile and Argentina, and guano from Peru, if they were available at all. Legumes were grown and/or farmyard manures had been applied. This meant that corn was grown on any one field area perhaps once every four or five years or longer.

The Second World War changed this scenario rather dramatically. After the war, the synthetic production of nitrogen fertilizers came on stream with startling suddenness. The cost and abundance of the nitrogen source were most attractive to farmers. Rapidly the idea flourished that no longer did farmers need to grow legumes such as alfalfa and red clover, nor did they need to keep livestock to produce farmyard manures. The cash crop system was here. The idea that structure-depleting crops such as corn and soybeans needed to rotate with soil-improving ones such as grasses and legumes was suddenly out-moded. The monoculture systems, such as growing corn continuously, was ushered into the crop production system. On many farms, when the livestock disappeared so too did the fencelines and farm boundary lines. They continue to disappear. In many areas, natural windbreak barriers such as woodlots and brushy field borders were removed, and in short order, 40 and even 80 hectare 'fields' became as commonplace as the 4 and 8 hectare ones were prior to the late forties and early fifties. Today, wide-open, unprotected agricultural lands exist throughout many areas of Southern Ontario.

Historically, wind erosion has been of concern mainly on sandy soils, and even there it was usually confined to knolls. During the past few years, however, wind erosion damage to both the soil and the crops grown thereupon has become an increasing concern on virtually all soil textures. This is especially true where the soil surface is bare or at best sparsely covered for much of the year. The frequency of damaging 'soil' storms caused by wind is certainly on the increase, and the possibility of getting a serious storm of this kind during any month of the year is stark reality. In fact, some of our most devastating soil-laden winds come, with increasing frequency, in mid-winter. The increased vulnerability of our soils to wind erosion, a reflection in large part of recent cropping and tillage practices, makes it imperative that solutions be found quickly.

One solution is the use of windbreaks to protect agricultural lands. In many areas, most of the natural windbreaks have been removed, protection which consisted of deciduous and evergreen trees in various stages of maturity along with a good undergrowth of shrubs. Even some mature evergreen windbreaks that were planted in the 1930's and 1940's have been cut down.

The Present Time

Many areas in Ontario are vulnerable to wind damage to our field, orchard and vegetable crops. This may be particularly true of early season vegetable plantings which are often grown on coarse-textured and/or organic soils. These soils often dry rapidly then wind scour easily. Many of the crops subjected to much wind damage are high value demanding the necessity of expensive cultural practices. This makes it rather imperative to use as many practices as necessary in order to protect our crops and soils from wind damage.

Planning, Design & Care Of Windbreaks

The planning and design of windbreaks are all important if maximum wind protection is to be gained. Solid, or very dense barriers are usually less effective than permeable types such as trees, small grains and corn. As wind strikes a solid barrier it is deflected over the barrier thus creating a wind turbulent zone in the lee of the shelter. The deflected wind returns to its normal speed in the lee of the windbrak at a much shorter distance than where only part of the air is deflected such as with semi-permeable or moderately dense barriers. Often the most desirable windbreak is one which has greater porosity near the ground.

Farmers interested in planning and planting windbreaks should contact the nearest office of the Ontario Ministry of Natural Resources or River Valley Conservation Authority. Tree Seedlings are available at a very nominal two and one-half cents per tree, plus a small handling charge.

Maximum windbreak protection may be obtained by planting the windbreak at right angles to the prevailing winds. On sandy soils, approximately 150 metres between mature windbreaks gives good protection to soil and crops, while on the fine-textured soils such as clay and clay loams this distance should be approximately 300 metres. Usually a two, or three row windbreak is recommended.

Several species of trees may be suitable for windbreak plantings, but some of the more desirable species in Southern Ontario are white spruce, Norway spruce, and white cedar. In the more Northern areas of Ontario, some desirable species are white spruce, black spruce and jack pine.

The key to successful establishment of trees for windbreaks is the proper care and maintenance of the young trees. Tree seedlings will establish and grow rapidly ONLY if grass and weeds are controlled and if the new plantings receive adequate moisture for the first 2 or 3 years. Weeds can be kept under control either mechanically, by hand or machine cultivation, or with chemicals. The herbicide, simazine is probably one or the most popular. Refer to OMAF Publication #75 - Guide To Chemical Weed Contol - for complete chemical weed control in shelterbelts.

Benefits

Much has been researched and written about the beneficial effects on crop yield and quality due to adequate protection from damaging winds. This holds true for field crops, orchard crops and vegetables.

Perhaps the easiest way to sum up and illustrate the response is diagrammatically (Figure 1). As can be noted there is often a yield reduction to the lee of the break just next to it. This reduction usually disappears at about the 1H area. Between the 1H to 12H area there is a considerable yield increase noted. The greatest increase occurs usually in 3H to 6H area. The crop yield curve in the lee of the windbreak is often quite similar to the that of wind reduction curve.

(A) Some of the major beneficial effects of windbreak protection are:

- Promotion of more even and rapid seed germination.
- Promotion of rapid plant growth.
- Better use of available soil moisture.
- Reduce soil erosion by water.
- Reduce soil erosion by wind.
- Reduce snow removal costs and inconvenience.
- Reduce heating bills (up to 30%)
- Reduce air-conditioning bills (up to 30%)
- Increased QUALITY and YIELD of produce.
- INCREASED PROFITS.

(B) Some major reasons for crop benefit are:

- Longer growing season.
- Reduction in evaporation rates in summer.
- Less stress from temperature variations.
- Better snow distribution.
- Less lodging loss.
- Reduction in soil abrasions to crops.
- Earlier ripening.
- More efficient use of soil moisture.

Conclusion

Wind protection may be provided by permanent 'living' windbreaks such as trees or perhaps temporary breaks such as small grains of other types of annual crops grown in strips across field. Artificial windbreaks * are also in use. Satisfactory windbreaks are made in Europe of black polyethylene film strips of 15 cm wide and 125 microns thick woven through 15 cm x 15 cm wire mesh netting at alternate intervals to provide a 50% porosity barrier, *(See Dr. F. Schales, Extension Vegetable Specialist, University of Maryland-American Vegetable Grower, Fe. 1984).

The use of windbreaks, permanent or temporary, living or mulch is only one of many techniques that growers can use to assist them in preventing wind damage to soil and crops. The use of other practices such as plastic mulches, individual and row covers, irrigation, raised beds, a timely cultivation, and perhaps even improved varieties, should also be considered.

One should also remember that adequate fertilization, neither too little nor too much, along with effective pest management practices all help to lessen plant stress thus help to offset the rigours of damaging winds.

The proper establishment and care of young trees in windbreaks and/or shelterbelts will reap remarkably early rewards to the farmer in the form of increased growth, reduced soil loss, improved crop quality and yield, and a gain in net profit.

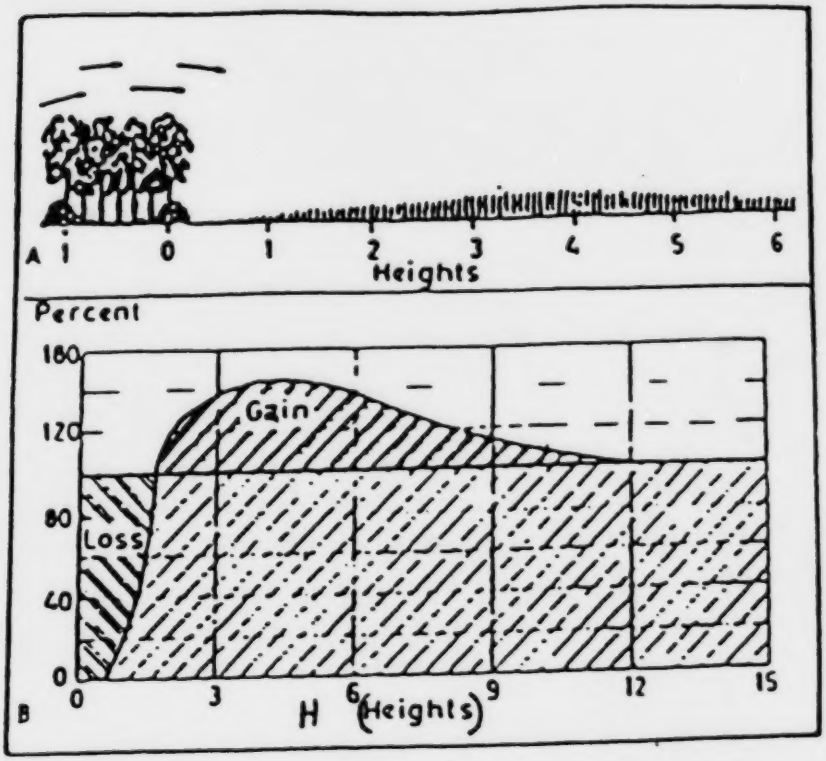

Figure 1 - Cross section of a windbreak and protected field. A=Windbreak and field crop in true proportions, B=Diagrammatic representation of the weight of the crop at varying distances from the break, (Bates, 1937).

H=heights of the windbreak out from the barrier.

BLACK SPRUCE GREENHOUSE TRANSPLANT SYSTEM DEVELOPMENT

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Abstract

Dryden started into the greenhouse transplant (GT's) system in 1980 using the cigarette paper plug (3/4") to grow 3G3+1.5 gene pool black spruce. From this experience the possibility of growing GT's operationally was envisioned.

Black spruce was grown using the operational system and compared to the GT system for quality standards and outplant survival. The results at the nursery were shown to the District field planting staff along with the one year outplant survival results in order that their input could be considered.

The GT system was found to have the capability of saving 117% of the land requirement versus the pure bareroot system. Individual system production costs were determined as follows:-

Ship Stock Age	Cost of Produce & Ship
1.5+1.5, 2+1	$171.04
GT's	196.20

Equipment development has kept pace with the GT cultural practices development to the point where a belly-mounted dibble unit will be tested in May of 1987.

The following operational black spruce products were decided upon in consultation with the Northwest Region's District planting staff, to be grown as 1.5+1.5 and 5G6+1.

The adopted age classes will continue to be monitored on the nursery during its growing phases for the required cultural adjustments. The ship stock quality will be monitored with its outplant survival in order that potential outplanting problems will be detected.

Only black spruce will be dealt with in this report. The other species test results are available from the report entitled. "Greenhouse Transplant System Development", Ministry of Natural Resources, Dryden Tree Nursery, by Terry Myland, April 1987.

Introduction

Initially Dryden got into the 'greenhouse transplants' (GT's) in 1980 for the production of approximately 1.0 million, gene pool black spruce, 3G3+1.5, using the Ontario 3/4" paper cigarette plugs. The objective was to maximize seed utilization in a fixed area and to produce sturdy plantable stock within a two year rotation versus the operational three year rotation. This project had several growing pains to overcome. Examples are:

1. Black spruce were culturally difficult to grow in cigarette plugs as the seedlings ranged from 1 to 8 cm at transplant time.

2. After the transplant stage, July, 1980, there was very little root egress through and beyond the non-decomposed paper plug (Domtar Paper, Montreal Development), which resulted in severe frost heaving by the late spring of 1981. The plugs were manually pushed back into the ground.

3. 1981 was the miracle year in which the root and top growth was phenominal producing 3G3+1.5, in contrast to the operational 2+1 and the trial 1.5+1.5 (1+2), Figure 1.

Following this experience and a trip to the Alberta Provincial Nursery to view the use of the Spencer Ferdinand plugs for GT's the decision was made to develop a GT system in Dryden. The Spencer Ferdinand plugs were selected for use in the greenhouse GT phase over the cigarette system as they were currently in use in Dryden and were producing good quality pure container stock to ship. The problem of root egress was eliminated using the Spencer Ferdinand plug versus the paper cigarette system. The operational GT development work started in 1982.

Purpose

To evaluate the GT system versus the current operational systems (pure bareroot) using the following criteria:

1. Nursery and District outplant survival and growth performance to be monitored in close collaboration with District staff for its value as a product to be planted on rich and shallow sites.

2. Seed utilization for GT's versus the pure bareroot system.

3. To increase the possibility that the assigned bareroot (B/R) target with the requested parameters would be achieved.

4. To increase the efficient use of nursery land, i.e. number of ship stock produced per hectare.

5. To have a cost effective GT system which would be operational.

6. To develop the proper operational equipment for transplanting the plugs.

Method

1. Black spruce was tried using several GT age classes for comparison to the operational age classes as shown in Table 1.

Table 1. Black spruce age classes shipped in 1985.

Operational:	2+1, 1.5+1.5
GT's	: 3G3+.5(1), 3G3+1.5(2)

2. The GT terminology used was as follows:

eg. 3 = Number of months in greenhouse
G = Greenhouse grown
3 = Month seeded
(1) or (2) = Number of years as B/R transplant

Note: Prior to standardization the last digit '1' above was often recorded to the nearest whole number even though the time period was only '.5' years.

3. The GT plugs were all grown operationally as per the appropriate year's cultural schedule in the Spencer Lemaire Ferdinand books.

4. The bareroot portion of the GT cultural schedule used was similar to the operational prescriptions.

The GT versus the operational systems (2+1, 1.5+1.5 or 1+2) were assessed for the following:

1. Nursery growth and district outplant survival and growth performance,

2. Seed utilization,

3. Land utilization,

4. Cost effectiveness and,

5. Availability of proper operational equipment for the transplant operations.

Results

1. General

Several of the method criteria: cultural practices, land utilization, production costs, equipment development and transplanting gave similar results for all species.

2. Cultural Practices

The greenhouse cultural practices evolved with gained experience during the period 1980-1986 as reported in the annual "Dryden Tree Nursery, Container Stock Reports", eg. extended greenhouse culture developed by S. Colombo.

The bareroot cultural practices used for the GT's were similar to the operational transplant system as reported in the annual "Soil Amendments and Pesticides". Form 1214 (3/79) reports.

3. Land Utilization

The GT system has 24.0 M seedlings versus the pure bareroot system with only 20.0 M seedlings per bed (150 lineal metres) which is a 17% loss in land utilization. The reason for the difference is the pure bareroot system is 8 row versus the 14 row for the GT system which maximizes land use.

4. Production Costs

The actual costs of the two systems are very difficult to tie down due to the complexity of prorating overhead costs (administration, container grower (M.N.R vs. Private). The 1.5+1.5 stock costs $171.04 M to produce and ship, while the 'GT' system is approximately $25.00 more to produce and ship.

5. Equipment Development

The GT's started in 1980 with a 12 row jump-dibble, (Figure 2), with 144 cavities made at each drop point. This system required four heavy and strong people to manually carry and jump on the dibble. The system worked, but was very labour intensive and monotonous.

During the summer of 1983 after investigating the types of transplanter units on the market, several different units were purchased and tested:

1. Lannen paperpot caroussel transplanter (Finnish).

2. Mechanical clip transplanter (two seater).

3. New Holland strawberry transplanter, similar to 2, but single seater.

4. Mechanical Transplanter (Model 3000).

The mechanical transplanter (model 3000) was the best of the four units tested. The physical size of the unit is a problem, as it would not permit a minimum of eight rows for transplanting within the standard 1.1 m beds with one pass of the transplanter unit.

In 1984 a 14 row dibble was developed to fully utilize the 1.1 m bed width. The dibble was mounted on the three point hitch of a tractor, which worked well.

During the winter of 1986 a belly-mounted dibble was placed on a small Farmall Tractor, (Figure 3), for trying in 1987.

The effective use of the multiple dibble unit to minimize hand dibble work required the following prescription to be followed:

1. Slowly rototill fresh soil to a maximum depth, approximately four beds in advance of the transplant.

2. Dibble a maximum of two beds ahead of the transplant crew.

3. The dibble must be inserted into the soil and completely remove from the soil in a vertical plane ONLY.

4. If the cavities start to dry out and collapse a five minute irrigation to be carried out.

6. Transplanting

The following steps are followed for the planting of each plug:

1. If the cavity formed by the operational dibble is too shallow then a hand dibble is used to deepen the cavity in the soil

2. Place the seedling plug into the cavity and cover the plug manually with soil using your fingers to seal the plug.

7. Evaluation

The transplantable 3G3 container stock was similar for all two ship age classes, (Figure 4), prior to transplanting in mid-July. Figure 5, shows the seedling 31 weeks after transplanting with major increases in R.C.D. and total oven dry weights.

Figures 6-9, show the parameters that all four age classes: 1.5+1.5, 2+1, 3G3+.5 and 3G3+1.5 exceeded the 13.0 cm height standard. Only the 1.5+1.5 and 3G3+1.5 exceeded the root collar diameter standard of 3.6 mm, and the total oven dry weight standard of 5.0 g. The 3G3+.5 and the 2+1 were within the maximum top/root ratio of 3.5.

All the age classes had a 96% or better survival after one year of outplanting in 1985 except for the 3G3+.5 which had an 84% survival.

The greatest seed utilization was with the GT system which required five seeds versus the operational bareroot (2+1, 1.5+1.5) which required twelve seeds to one ship tree.

Conclusion and Recommendations

1. General

All of the following remarks are based upon the experiences of the Dryden Tree Nursery and the Northwest Region's District planting staff which were used to formulate the future operational direction for the Region's bareroot and container stock programs.

2. Land Utilization

With the utilization of a one year GT system versus the operational 1.5+1.5 system a land saving of 100% results due to the extra half year required by the 1.5+1.5 system. The 100% gain would be further enhanced by approximately 17% due to the greater ship density of the GT's (i.e. physical number of trees per lineal meter and the survival percent of trees per lineal meter is greater).

3. Production Costs

The GT versus the 1.5+1.5 system is $25.00 per thousand more for a shippable product. The reliability of producing the GT's for quantity and quality makes this product worth the extra dollar investment to produce.

4. Equipment Development

The testing of the belly-mounted dibble unit in 1987, if it is possible, would mean cleaner cavities, which would drastically reduce the hand dibbling and would also be reflected in future transplant contract savings.

5. Black Spruce

Operationally the 2+1 stock was dropped as it was very dependant on the one year transplant growing season, which often resulted in cull rates in excess of 40% due to the lack of height.

The 3G3+.5 was too small a product versus the 3G3+1.5 which was too large a product for the districts to plant. The decision was made to go with a marriage of the two systems to produce 5G6+1 stock which would give a more balanced product.

The operational 1.5+1.5 gave an acceptable and a dependable product from several years of trials. As such, the districts accepted the 1.5+1.5 as an operational product also.

Due to the prohibitive capital cost requirements to produce operationally 5G6+1 only, a blend of 1.5+1.5 (2.5MM) and 5G6+1 (1.5MM) were set for annual targets. The production of the 5G6+1 would permit the nursery to maintain its 7.0 MM total ship target with the dropping of the 2+1 system. The first fully operational transplanting will occur in May 1987 using the 5G6+1.

6. The black spruce GT system was preferable to the white spruce for the following reasons:

1. Black spruce requires 12 seeds for 1.5+1.5 while white spruce requires 9 seeds for 1.5+1.5 versus the 5 seeds for GT's to produce one ship tree,

2. The white spruce has been more consistent for achieving target as pure bareroot stock versus the black spruce,

3. The black spruce seed bank is very low compared to the white spruce seed bank.

4. The one year GT system gives greater flexibility for the production of black spruce to ensure that the targeted quantities and quality are available. Table 2 models out the added two years of flexibility for the production of the bareroot target numbers and quality.

Table 2. One to Two Years of Seeding Flexibility for a Normal Three Year Rotation.

Year	Inventory Year	Target vs. Projected ship Shortfall (M trees)	C/S Crop Makeup Seed:		C/S Transplant for ship as:	
			June	March	5G6+1	3G3+.5
1	1+0	X1				
2	1.5+1.5	Y1	X2			
3	1.5+1.5			Y2	X3	Y3

Note: 1 - shortfall determined
2 - seeding C/S for B/R shortfall
3 - transplanting C/S for B/R ship

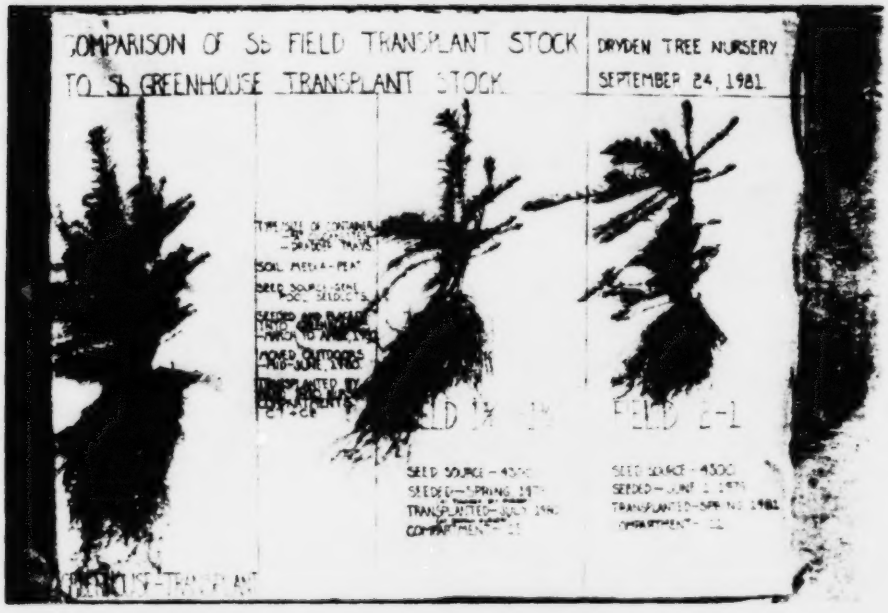


Figure 1. Comparison of black spruce transplant stock to greenhouse transplant stock.

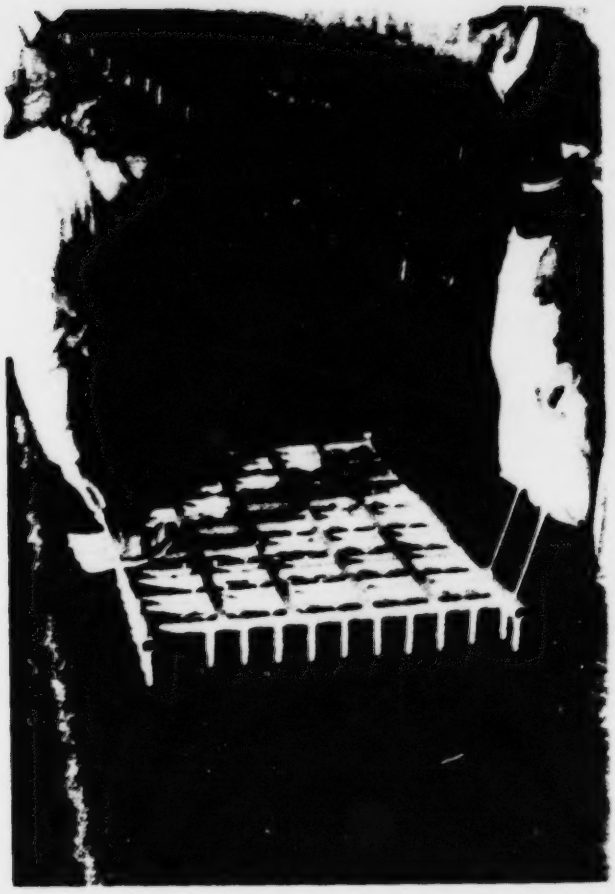


Figure 2. Twelve row jump dibble with 144 cavities at each drop point.

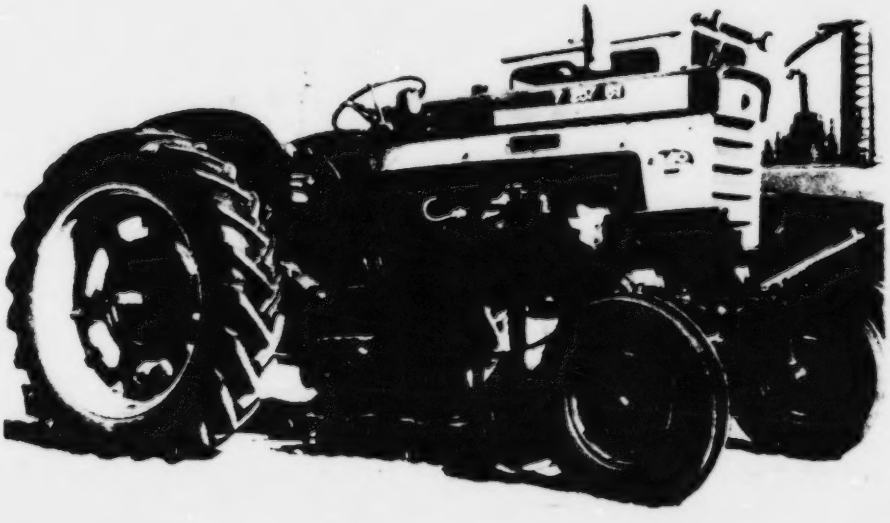


Figure 3. Hydraulically operated belly-mounted dibble.

Figure 4. Average black spruce (83-1), A.T.P., at the end of greenhouse phase.

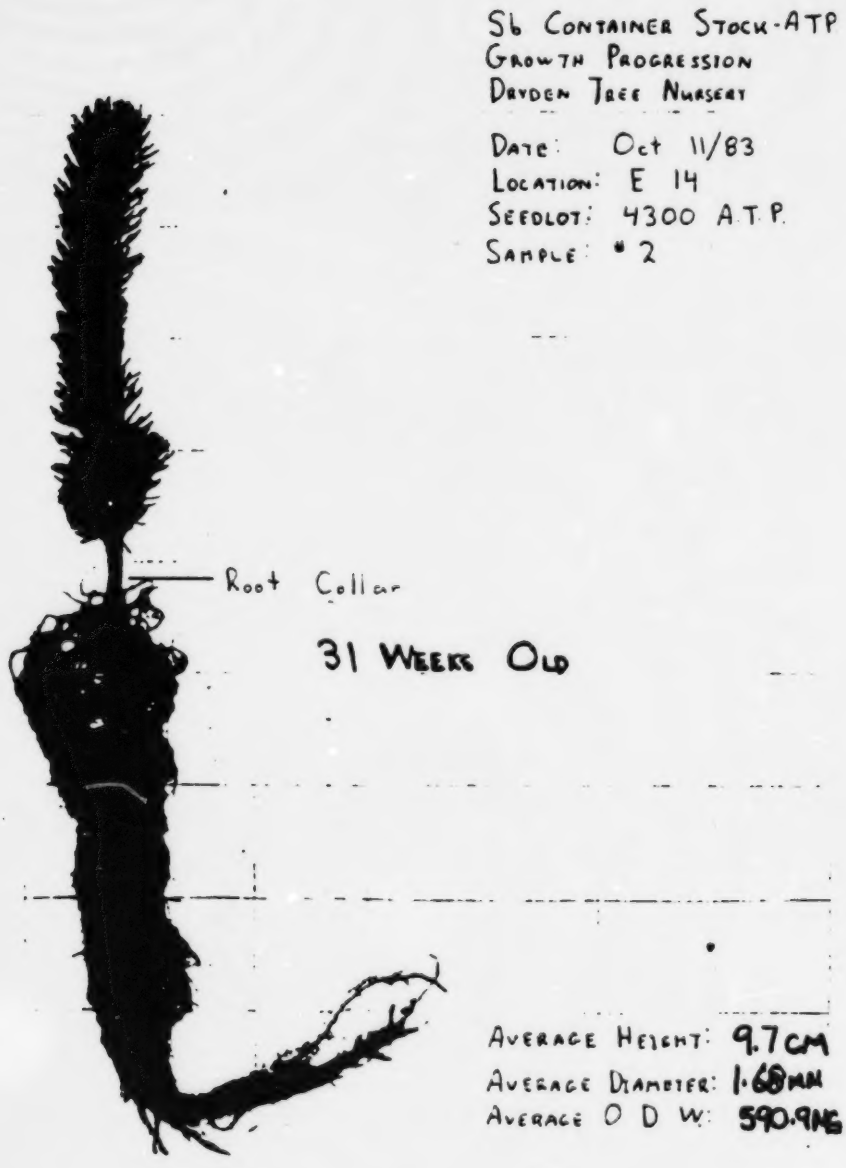


Figure 5. Average black spruce (83-1), A.T.P., fall field sample.

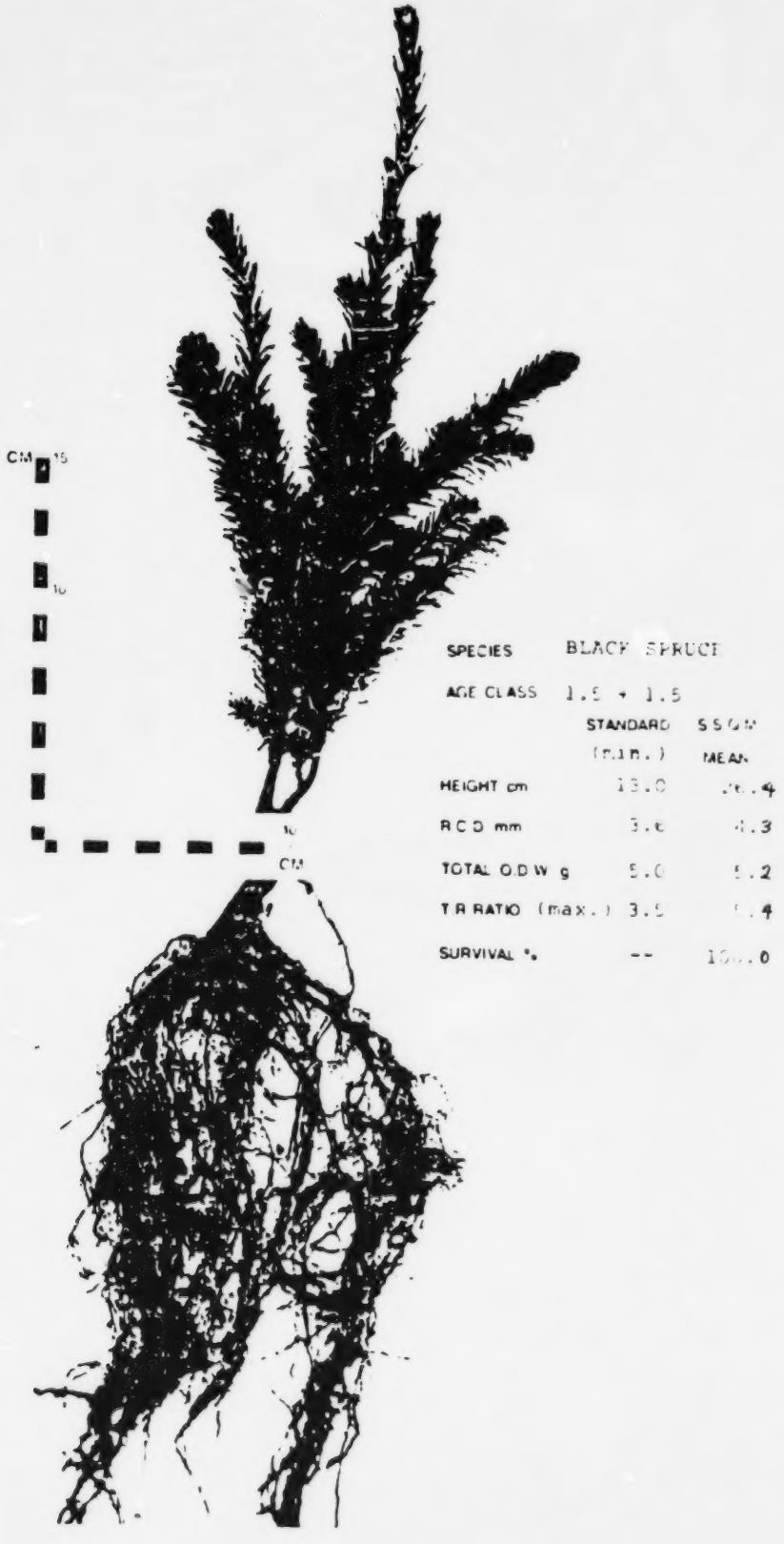
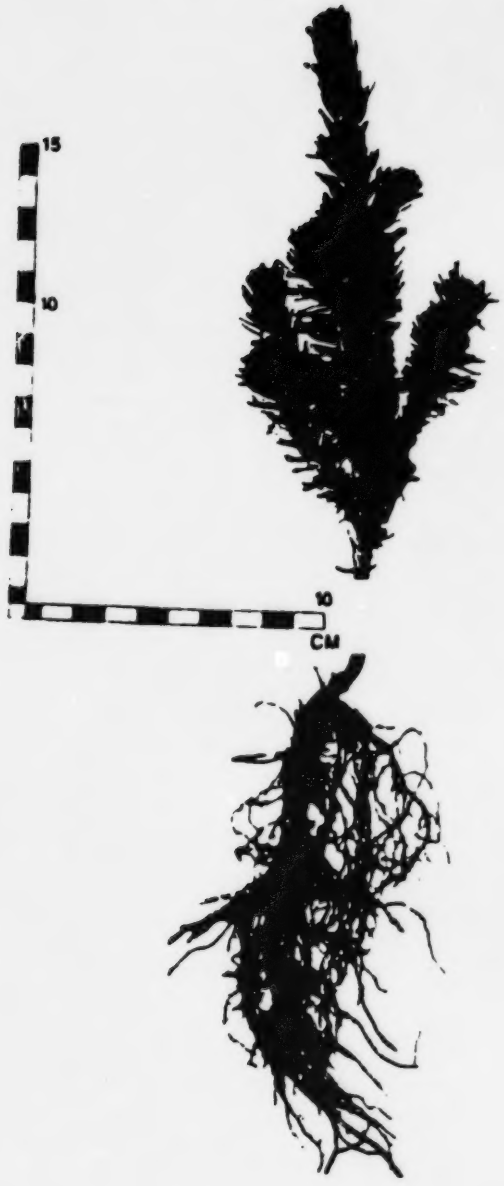
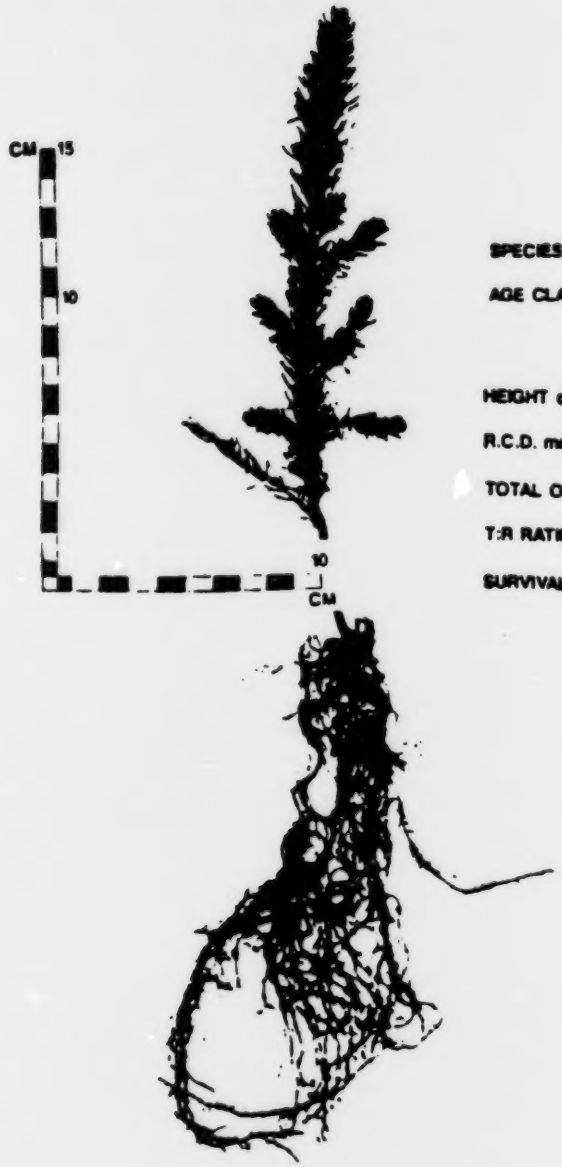


Figure 6. Comparison of bareroot shipping stock standards (1.5+1.5) versus ship stock quality monitoring (S.S.Q.M.)



SPECIES	BLACK SPRUCE	
AGE CLASS	2 + 1	
	STANDARD (min.)	S.S.Q.M. MEAN
HEIGHT cm	13.0	14.1
R.C.D. mm	3.6	2.8
TOTAL O.D.W. g	5.0	1.7
T:R RATIO (max.)	3.5	3.3
SURVIVAL %	--	96.0

Figure 7. Comparison of bareroot shipping stock standards (2+1) versus ship stock quality monitoring (S.S.Q.M.) and first year survival after outplanting.



SPECIES	BLACK SPRUCE	
AGE CLASS	3G3 + 0.5	
	STANDARD (min.)	S.S.Q.M. MEAN
HEIGHT cm	13.0	17.5
R.C.D. mm	3.6	3.0
TOTAL O.D.W. g	5.0	2.0
T:R RATIO (max.)	3.5	2.8
SURVIVAL %	--	96.0

Figure 8. Comparison of bareroot shipping stock standards (3G3+0.5) versus ship stock quality monitoring (S.S.Q.M.) and first year survival after outplanting.

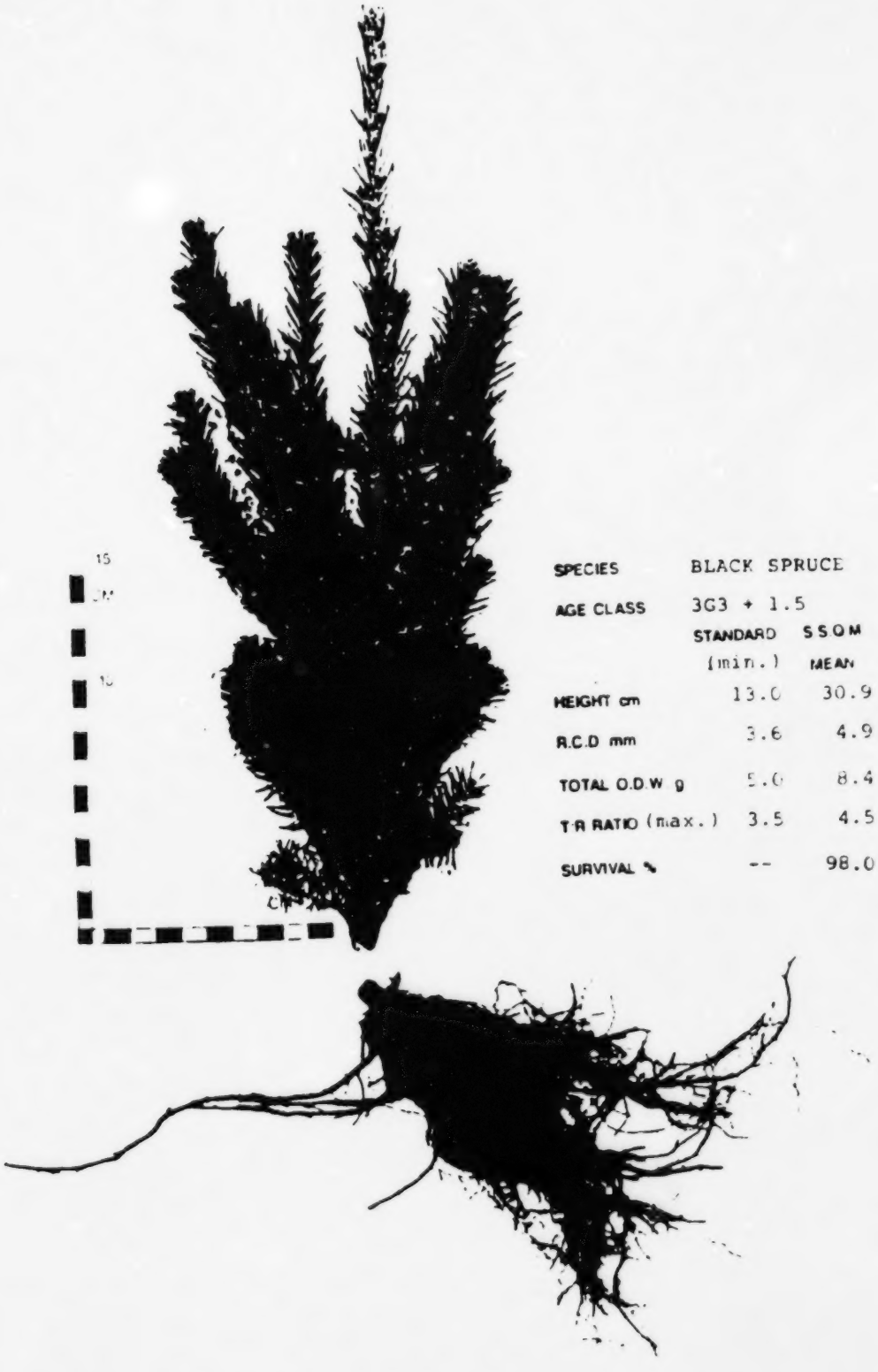


Figure 9. Comparison of bareroot shipping stock standards (3G3+1.5) versus ship stock quality monitoring (S.S.Q.M.) and first year survival after outplanting.

GREENHOUSE TRANSPLANT PROGRAM

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Abstract

Swastika Tree Nursery first began experimenting with greenhouse transplants in the mid 1970's. Since 1983 approximately 8 million transplantable trees have been produced per year using a two crop system. Seedlings are grown in paperpot trays without the paperpot set. Seeds are sown using a 308 paperpot seeding head. When a crop is ready for transplanting the seedlings are removed from the trays and packed into tubs for immediate transplanting or into boxes for frozen storage. One of the advantages of this system is that conventional container technology can be adapted to produce bareroot seedlings. Also, conventional Holland transplanters can be used for transplanting.

The use of existing technology eliminates the need for the large capital expenditures generally associated with the development of new transplant technology.

Greenhouse Operations

The seeding and filling of trays is done in a growing medium preparation and seeding building. The building is equipped for growing medium preparation, filling, seeding, sanding and has a dust collecting system. The system has a capacity for 1200 trays per day for 600,000 greenhouse transplants. The production target of transplantable trees for the first crop is 4.28 million, and the second crop is 3.99 million for a total of 8.3 million.

The greenhouse program consists of 2 Gro-Mor Greenhouses, each occupying 400 square metres of growing space, with a capacity of 960 paperpot trays. The Gro-Mor houses feature an all electric system providing automatic temperature control by thermostats. The heating system is hydronic using 4-546 litre hot water units with 125 m of finned pipe, one run on each side and in the center of each greenhouse. There are also 12 smaller greenhouses, (Vary Greenhouses), each having 268 square metres of growing space with a capacity of 600 paperpot trays each. These houses have automatic temperature control by the use of thermostats, and are heated with propane furnaces.

The growing season starts in mid-March and ends in mid-November, with two crops per greenhouse being produced. The first crop is seeded in mid-March and moved to the holding area in early June. Once in the holding area, the crop is covered with a 47% shadecloth. After a two week period when desired parameters of the seedlings are reached, an 8 hour photoperiod is used on the seedlings. This is done with the use of a 100% shadecloth placed over the seedlings. After one week of photoperiod control the seedlings initiate bud. High levels of frost hardiness are achieved sooner, the earlier the buds are initiated. The second crop is seeded early June and the seedlings remain in the greenhouse until the first week of November when frost hardiness tests show less than 5% damage at -10°C. The seedlings are graded and placed in cold storage (-3°C) until transplant time the following spring.

Growing Medium (GM) Preparation System

The growing medium used at Swastika consists of 65% sphagnum peat moss, and 35% vermiculite.

The peat moss that we use has the brand name Fafard and comes from a bog in Senniterre, Quebec.

The pH of the GM, once it is mixed, is generally around 4-4.2. Once we start fertilizing and watering, the pH tends to come up to around 5.5-5.8. The pH of our irrigation water is 7.0

The GM preparation system consists of a series of bins and augers. There is a separate bin for the peat moss, one for the vermiculite and one for the mixed product.

The peat moss is augered from the peat moss bin through a shredder where a lot of sticks and branches are screened out. By going through the shredder, the peat moss takes a more uniform structure.

After going through the shredder, the peat moss is then augered past a vermiculite proportioner. This proportioner can be set to whatever percentage of vermiculite desired. There is also a series of water nozzles located prior to the addition of vermiculite which can be incorporated to the moss.

There is a separate bin for the mixed product (GM). From this bin the GM is then augered to a Lannen filling line.

A bucket conveyor takes the trays through the filling line and the GM collects on top of the trays. A series of brushes pack it into the trays and any excess is brushed aside. There are hoods on the filling line that isolate dust and noise. From here the trays move on a Lannen Sator 5 seeder.

The seeder works on a vacuum principle. There are nozzles located on a moveable frame. The seeded tray then moves on to the sanding machine. This system consists of a bin which holds the sand (a #10 grade silica sand) and a screw feeder, feeding a small hopper. As the tray moves toward the silica bin, it triggers a photo electric eye which activates the small hopper to dispense the silica over the tray.

A dust collector is also a part of our GM preparation system which collects dust from the various loading bins (peat, vermiculite, sanding). The seeded trays are then placed on pallets (3 trays to a pallet). The pallets are stacked five high and by means of a small tractor with forks, transported to the greenhouse. The trays remain on the pallet and are placed on the floor of the greenhouse.

Fertilization Procedures

1) April Sowing - Greenhouse Transplants, G+1.5

The sowing takes place during the last week of March and the first week of April. Application of fertilizer begins one week after 10% germination, which is approximately 17 days after the sowing date. A high phosphorous fertilizer usually 10-52-10 or 7-40-17 is used first at a rate of 50 ppm N for 2 applications followed by 4 applications at 100 ppm N. The high phosphorous is used to promote root development. The fertilizer is applied over 4 passes which is approximately 2000L of solution, followed by one pass 500L of water. This fertilizer is applied every three or four days with a Gewa fertilizer injector. Then we start using 20-20-20 fertilizer at 150 ppm N. The fertilizer is used during the period of vegetative growth after the seedling has a well established root system. There are usually 7 applications every 4 days during the first three weeks of May. But beginning with the last week of May and for the month for June, 6 applications of high potassium fertilizer, usually 4-25-35 or 8-20-30 is applied. The high potassium fertilizer helps to harden the seedlings. The crop is then graded and transplanted during the second week of July and remains in the nursery field for 1 1/2 years.

2) June Sowing - Greenhouse Transplants, G+2

The sowing takes place during the first week of June and the fertilizer is applied one week after 10% germination. The crop receives 6 applications of a high phosphorous fertilizer, usually 10-52-10 or 7-40-17, at 50 and 100 ppm N. The crop then goes on a balanced schedule during the period of vegetative growth receiving approximately 10 applications of 20-20-20 at 150 ppm N. A high potassium fertilizer, 4-25-35 or 8-20-30 is then used during September to harden up the seedlings. There are 3 or 4 applications of this fertilizer.

Growth Progression

The growth progression begins 5 weeks after 10% germination and is done every 2 weeks until mid-June, then is done every week. A total of 20 samples are taken and the GM collected is used for salt and pH readings for that crop.

Pesticide Applications

Pesticides are applied through the Gewa fertilizer injector. In 1986 mites were a problem and the miticide Pentac was used at 650 mL per 1000 L of water. Preventative spraying is done on the second crop for botrytis. This is done in mid-September every 14 days to late October with Daconil or Braco at a rate of 1500 mL per 1000 L of water.

Cold Hardiness

Cold hardiness tests begin in October and by the first week of November when tests show less than 5% damage at -10°C the trees are graded and placed in cold storage at -3°C. The crop is then transplanted the following spring and remains in the nursery field for 2 years.

Transplanting Parameters

The transplanting parameters used at transplant time are:

Shoot Ht	10 - 13 cm
RCD	1.2 - 1.4 mm
ODW	205 mg
S/R	6.0:1

Grading

The grading for the mid-March sown crop takes place during the first week of July and for the June sown crop the first week of November. An average of 22,000 trees per person per day are graded, that amounts to 4 million trees in one week.

Costs

The cost to load, seed and tend:	$21.06/1000
maintenance cost	7.43/1000
grading cost	5.50/1000

The total cost up until transplant time is $33.99 per thousand.

Trials

Trials being conducted for the 1987 growing season include:

1) 2 and 3 times normal fertilizer rate

2) Constant feed program for 2 houses

3) Using of target forest sand (1/2 house)

4) Osmocote pellets, 3-4 month formulation (50 trays)

TECHNICULTURE TRANSPLANTS

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Abstract

The intended goal in introducing the Castle and Cooke Techniculture transplant system at the Thunder Bay Forest Nursery was to improve our reliability in achieving production targets. Observations from our tests, trials, and experiences allow us to revise the list of advantages of the Techniculture system to be expanded to include:

1. Improved reliability in achieving targets
2. Increased production capacity of the nursery
3. Better seed utilization
4. Improved stock quality
5. Improved operating efficiency

Introduction

In reviewing the record of performance of our nursery, it quickly becomes apparent that over the years we have not been very reliable in achieving our production targets. From 1975 to 1983 we have produced only 70% of requirements and during the decade prior to that when the 3+0 seedling was our major product, the actual achievements were much more erratic ranging from 36% to 115%. With this kind of delivery, it is extremely difficult for our clients to do the necessary planning for plantation establishment. About 70-75% of our production is transplant black spruce. Traditionally it has been grown in a seedbed for 1 1/2 years then lifted, sorted, graded, and transplanted into another bed where it grows for another 1 1/2 years. An investigation of the cause of the erratic performance leads directly to the seedling stage of production. Even though we have been sowing about 12 seeds to produce one shippable tree the fluctuations in the natural elements working against us makes our attempts at inventory control quite futile. From our investigation it became quite apparent that by moving our "seedbed" indoors we could achieve the reliability that is required.

Many different techniques and systems in producing transplants in the greenhouse have been investigated at various nurseries in recent years. In looking at the alternatives it became apparent that by selecting the correct method we could achieve much more than our goal of reliability. The system that appeared to offer the most was the Techniculture System developed by Bud Antle of California.

The Advantages Of This System

1. Improved reliability achieved through:

   - very accurate/absolute control over numbers of trees produced in the greenhouse.
   - very accurate transplanting inventory
   - avoidance of traditional first year disasters which can cause tremendous irreplaceable reductions in inventory
   - increased yields (fewer culls)

2. Increased production capacity achieved through:

   - a shortened rotation (3 years reduced to 2 years)
   - freed up seedbeds (9 compartments vacated)

3. Better seed utilization (12 seeds/shipped tree reduced to 3 seeds/shipped tree achieved through:

   A. Improved germinating conditions, by:
      - better seed placement (with respect to spacing, depth and coverage)
      - eliminating mulch (which is somewhat restrictive)
      - eliminating herbicide application (with its toxic effects)
      - absolute temperature control
      - controlled irrigation/moisture levels
      - uniform growth progression (minimize phenotypic variance)
      - avoid restrictions from debris in seed bed.

   B. Improved growing conditions, by eliminating or avoiding:
      - losses due to pathogens
      - losses due to insects
      - losses due to rodents/animals
      - losses due to birds
      - losses and dislodging from hand weeding
      - losses due to trampling and driving over
      - losses from toxic herbicides
      - losses from damage of shades and their supports
      - extreme moisture conditions

- wind/sand blasting
- leaching/loss of nutrients
- sun scald/wind burn
- late spring frost damage to germinants and to 1 year old stock
- frost heaving

4. Improved stock quality achieved through:

- avoidance of "J-root" or "hockey stick" distortions induced by the Holland transplanter
- continuity of growth in actively growing trees
- no "strees" period as root exposure is minimized
- eliminating root pruning and possible entry of organisms
- transplanting in spring puts seedling in sync. with nature permitting better bud development and hardiness
- seedlings transplanted early in the season permits good anchoring and reduces frost heaving
- more desirable product (root mass and top/root ratio)

5. Improved efficiency achieved through:

- reduced seed requirement
- reduced production costs of the transplants
- reduced transplanting cost
- faster, more efficient harvesting rates
- fewer culls, with possibility of bed run harvest

THE BENEFICIAL EFFECTS OF STRATIFICATION ON TREE SEED GERMINATION

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Abstract

Stratification is commonly used to break dormancy in seed. Stratification results in vigorous, speedy, maximum, and uniform germination for laboratory testing, and greenhouse and nursery sowing. This paper reviews the established methods, conditions, and beneficial effects of stratification. It discusses the various critical factors affecting seed stratification and its newly-found advantages in minimizing differences in germination due to the degree of seed maturity, handling and processing. It also discusses precautions for handling and storing stratified seeds.

Introduction

Canada is increasingly turning to intensive forest management to meet the increasing demand for forest products and for environmental protection. We used 5.3 billion viable seeds for reforestation purposes in 1982/83 (Janas 1985). And it is estimated that the number of viable seeds needed for forest renewal is expected to reach 7 billion by 1987 (Morgenstern 1986).

However, seed efficiency, in terms of percentage of shippable seedlings produced from the number of viable seed sown, has been low in many provincial nurseries (Skeates and Williamson 1979) and much improvement is necessary. Such an improvement is especially important to future planting stock production when valuable genetically-improved seeds will become available (South 1986). There are many factors causing low seed efficiency in stock production, and one of the key factors identified is seed pre-treatment, especially pre-treatment to overcome dormancy and enhance the rate of germination, uniformity, and total germination by stratification.

This topic has been previously discussed and reviewed by Allen (1954, 1958, 1960, 1967), Kester (1960), Reisch (1962), Nikolaeva (1969), and Pellett (1973). This paper reviews recent progress in seed stratification and discusses how it may affect seedling production in the greenhouse and nursery.

Objectives of Stratification

Procedures for stratification, also known as "after-ripening," has been developed through observation, experiment, and experience (Allen 1967) and are commonly used to overcome various types of seed dormancy (Nikolaeva 1969, Allen 1967, Pellett 1973). Recently, it was found that cold stratification, or prechilling provides other beneficial effects on seed germination (Wang, unpubl. data). These effects will be discussed later.

The process of stratification-germination of dormant seeds occurs in three well-defined phases of dormancy release (Webb and Dumbroff 1969, Dumbroff and Webb 1970, Dumbroff and Silva 1972, Lewak and Rudnicki 1977, Nikolaeva 1977). The first phase is concerned primarily with enzyme activity and hydrolysis of storage products with the rate of activity controlled by the restricted movement of water through the covering structures (i.e. pericarp in Amur maple and testa in sugar maple seeds). This phase is characterized by a rapid initial increase in water uptake, respiration, and soluble nitrogen. The second phase is a period of active synthesis which signals a transition from the dormant to the non-dormant state of the seeds. It is characterized by a plateau in water uptake and respiration, and a dramatic decline in total soluble nitrogen and amino nitrogen. In this phase there is marked increase in translocation of nitrogen from the cotyledons to the embryonic axis. The third phase represents the main germination process. It is characterized by a rapid increase in water uptake, respiratory activity, and soluble nitrogen.

Beneficial Effects of Stratification on Seed Germination

(i) Breaking Seedcoat and Morphological Embryo Dormancy

This is mainly concerned with seeds whose woody endocarp inhibits germination by mechanical resistance to embryo growth, or seeds whose embryos are underdeveloped and require post-development to complete cell complexes. For example, the dormancy imposed by mechanical resistance of the stones within Elaeagnus seeds is usually overcome by warm stratification and its effectiveness increased when peat is used as a stratification medium (Nikolaeva 1969). Seeds with immature or underdeveloped embryos require warm and/or cold stratification to further develop their embryo size and to differentiate their organs (Nikolaeva 1977). Cell complexes are formed during the maturation process in Tatarian maple (Acer tataricum) seeds and at the end of the warm and the beginning of the fold stratification period in Euonymus europaea. In European ash (Fraxinus excelsior) seeds the cell complexes are completed after three months exposure to warm temperatures and continued over all subsequent stratifications (Nikolaeva 1977). In the case of eastern red cedar, a warm/cold stratification, combination of four weeks at 24°C and 12 weeks at 5°C, is required (Barton 1951, van Haverbeke and Comer 1985). In some species post-harvest ripening is completed with the rupture of the seedcoat resulting from water uptake and an increase in volume of the endosperm.

(ii) Increased Rate of Germination, Uniformity of Germination, and Total Germination

It has been clearly demonstrated that application of an appropriate period of cold stratification to physiologically dormant seeds will result in increased rate of germination and uniformity, as well as increased total germination (Allen 1954, 1958, 1960, 1967, Stokes 1965, Nikolaeva 1969, 1977; Pellett 1973, Lewak and Rudnicki 1977, Wang et al. 1982, Wang and Pitel, in prep.). Cold stratification can also improve the rate of germination of nondormant seeds such as Pinus banksiana, Pinus resinosa, and Picea mariana (Wang, unpub. data) (Figures 1 and 2). The rate of germination is enhanced with the increase in duration of the cold stratification period within the limit of a given species (Barton 1928, Allen 1958, 1960, 1967). For Douglas-fir, 150-day-stratified seeds from various provenances had the fastest rate of germination at 10°C to 25°C (Allen 1960). According to Hellum and Dymock (1986), the rate of germination of 42-day-stratified lodgepole pine seeds was significantly better than those with 21-day-stratification. Under standard laboratory test conditions (ISTA 1985), shallow or nondormant seedlots of eastern white pine (Pinus strobus) and white spruce (Picea glauca) completed their total germination in 28 days and 21 days respectively, following two week cold stratification, but attained their maximum rate of germination after 56 and 84 days in cold stratification respectively (Mittal et al. 1987).

The beneficial effects of germination speed or rate (as a result of cold stratification), on nursery-grown seedling quality and quantity were reported by Venator (1973) for Caribbean pine (Pinus caribaea), Mexal (1980) and Barnett and McLemore (1984) for loblolly pine (Pinus taeda), and Logan and Pollard (1979) for Japanese larch (Larix kaempferi). In a recent publication Boyer et al. (1985) revealed the significance of germination rate on seedling diameter of nursery grown loblolly pine at lifting and stressed the importance of optimum stratification periods.

(iii) Widened Temperature Range for Germination

Prior to cold stratification pretreatment, dormant seeds are only capable of germinating within a narrow range of temperature regimes near the optimum. Following cold stratification, seeds are capable of germinating under a much wider range of temperatures, and the longer the stratification period the colder the temperature under which the seed can germinate. This characteristic of stratified seeds was reviewed by Vegis (1964) and Stokes (1965), and demonstrated by Allen (1958, 1960) for Douglas-fir (Pseudotsuga menziesii) and true firs (Abies spp.), by Gosling (unpubl. results) for non-dormant sitka spruce (Picea sitchensis), and by Wang (unpub. data for Eastern White Pine (Figure 3). As pointed out by Allen (1967), early germination or seedling establishment, resulting from fall sowing or spring sowing of cold stratified seeds, should not be underestimated. Also, no alternative treatments to cold stratification will have such marked effect on the temperature requirement for germination.

(iv) Modified Light Requirement For Germination

The significant effect of light on seed germination has long been recognized (Mayer and Poljakoff-Mayber 1975). Heit (1961, 1968) tested light requirements for the laboratory germination of 93 trees and shrub genera and species and found 47 requiring artificial light for maximum germination. However, seeds sown for seedling production under both greenhouse and nursery conditions are usually covered by soil and/or other material such as perlite and their light requirement for maximum germination are not met. To reduce the light effect on germination, seeds should be stratified at 1°C to 5°C for appropriate periods of time. Apparently, cold stratification can make seeds become light independent for germination, as shown by Figure 4 (Wang, unpub. data).

Modified light requirement for germination by cold stratification in some seed species is inter-related with temperature effects (Stokes 1965). For example, Black and Wareing (1955) found that freshly collected Eruopean birch (Betula pubescens) seeds will germinate at 15°C only under long-day conditions, at 25°C under long and short days, and, at higher temperatures, even under continuous darkness. When seeds are stratified, they will germinate in darkness at all temperatures and also at 10°C. Similar light-temperature interactions affect germination of Betula populifolia and B. lenta seeds, although germination of unstratified seeds was enhanced by increasing photoperiods which apparently counteract the low temperature effect (Vaataja 1956).

(v) Reduced Effects of Seed Maturity, Handling and Processing on Germination

Cold stratification can also affect the germination of seeds that are apparently mature but which require post-harvest ripening to complete their cell complexes, as exemplified by the white spruce seed in Figure 5. This figure shows the effect of cold stratification on the germination of white spruce seeds extracted from cones collected from the Petawawa Research Forest from August 27 to September 7, 1984 and air-dried in a cone shed for 12 to 42 days (Carron and Schooley, unpublished data). It is obvious from Figure 5 that germination of the seeds extracted from 12-23 day air-dried cones was greatly enhanced by the cold stratification at 2°C to 4°C.

In any provincial seed extractory, cones of the same species but from different locations are not only collected at different times but also handled and stored differently before they are transported to the seed plant for processing. The diversified collecting, handling, and storing techniques at collection sites invariably cause differences in seed quality for germination. Such differences in handling cause pronounced effects in the germination of unstratified

seeds but completely or partially disappear after an appropriate period of cold stratification. This is demonstrated in Figure 6, which shows that the effects on unstratified seed of different handling and processing techniques of several lots of white spruce cones by two seed extraction plants are diminished or minimized after 21-day cold stratification.

(vi) Cold Stratification as a Seed Vigour Test

When it is properly carried out, cold stratification does not have any detrimental effects on the germination of high quality seedlots, although it was reported to have lowered seedling production for poor-quality seedlots (Allen 1967). For example, Hellum (1968) found that 2 to 112 day cold-stratification had detrimental effects on both the rate and total germination of white spruce seeds from Southwestern and Central Alberta. A similar case with slash pine (Pinus elliottii) seeds was reported by Donald (1968). However, we have not experienced corresponding situations with seedlots of various species over the years in the National Tree Seed Centre, except those which are aged and deteriorated, or damaged by improper handling and processing.

If cold stratification can have negative effects on the germination of aged and weak or damaged lots, it could be used as a vigour test to detect and weed out low-vigour seedlots for reforestation purposes (Allen 1960).

Stratification Conditions

To obtain consistent, effective cold stratification results, the following essential conditions have to be fulfilled and standardized.

(a) Moisture Requirement

Metabolic activities in the seed cannot proceed without moisture. The amount of moisture required for effective stratification does not seem to be critical, provided it is above the minimum level and does not affect the access of air (Stokes 1965). For loblolly pine seeds, peat or sand wetted to 25, 50, 75, and 100% of their water-holding capacities were all equally effective in meeting the stratification requirement (MacKinney and McQuilkin 1938). The currently recommended presoaking period of 24-48 hours in tap water at room temperature will enable most coniferous seeds to increase their moisture content to 30-50% (fresh weight basis) (Allen 1967).

However, excessive moisture can be detrimental, possibly due to reduced access of oxygen (Stokes 1965), especially when seeds are "naked" stratified in plastic bags. It should be noted that presoaking seeds at room temperature is good for species such as basswood (Tilia americana) but is unfavourable for others (e.g. sugar maple) if cold stratification is planned (Stockes 1965, Janerette 1978).

(b) Low Temperature Requirement

According to Stokes (1965), cold stratification characteristically takes place at temperatures between 1°C and 10°C, but is most effective and rapid between 2°C and 5°C. The prescribed temperatures for cold stratification to overcome dormancy in tree seeds for laboratory germination tests are 1°C to 5°C (Bonner et al. 1974, AOSA 1984, ISTA 1985). Wareing and Villiers (1961) effectively stratified European ash (Fraxinus excelsior) seeds at 0°C to 1°C.

The stratification temperature influences subsequent germination speed and time of completion and, for some species, germination during prolonged stratification periods. Danielson and Tanaka (1978) found that ponderosa pine and Douglas-fir seeds stratified at 5°C germinated faster and completed germination earlier than those stratified at 2°C. They emplasized the importance of temperature control during stratification in preventing germination during stratification.

Although presoaking seed of several conifers in aerated water was found beneficial (Fowler 1969, Barnett 1972), sugar maple seeds seem to favour presoak in water with lowered oxygen availability (Janerette 1979).

Freezing and below freezing temperatures (-3°C to -5°C) are not only ineffective for cold stratification but also result in injury to imbibed seeds (Baldwin 1942, Stokes 1965).

(c) Adequate Aeration

Oxygen is essential for effective stratification because it facilitates seed respiration and allows for the escape of carbon dioxide and heat, preventing development of anaerobic conditions. This is especially important when stratifying large quantities of seeds in plastic bags for prolonged periods. In such cases, the sound practice of frequently opening and shaking of the bag to facilitate air exchange should be followed.

According to Nikolaeva (1969), the conditions of aeration during cold stratification treatment have a profound effect on the rate of stratification. In her study on the influence of deteriorated aeration during cold stratification on germination of tatarian maple (Acer tataricum), she found that the negative effect of impaired aeration was more evident when it occurred at the beginning two months than at the latter two months.

(d) Control of Fungal Infection

The presence and pathogenicity of key fungi on spruce and pine seeds have been recently reviewed by Mittal and Wang (1986, 1987). Some seed-borne fungi were found to develop and spread during cold stratification and caused germination failure (Epners 1964). Although some key seed-borne fungi such as Alternaria, Fusarium, Mucor, and Penicilium were found capable of developing and spreading during prolonged periods of cold stratification of eastern white pine and, to a lesser degree, of white spruce, they did not affect the rate or the total germination of seed. But they did affect seedling quality (Mittal et al. 1987). A recommended effective control method is to surface sterilize the seeds by a 10 minute soak in a commercial solution of sodium hypochlorite, diluted to 2% available chlorine, before cold stratification (Annon. 1965, R.K. Mittal, pers. comm.).

A pathogenic seed-borne fungus, Calocepha fulgens, commonly known as cold fungus, was found in 25% of all stored spruce, Douglas-fir, and grand fir seedlots in British Columbia, and caused significant pre-emergence losses of seeds of these and other species during cold stratification, both in cold storage and in seedbeds (Salt 1974, Sutherland 1979, Suthland and Eerden 1980.) Because this fungus infects seed through collected cones from the ground or squirrel caches, recommended control measures include avoidance of cones harvested from the ground or squirrel caches and stratification of seeds without medium (Suthland and Eerden 1980).

(e) Optimum Duration

Optimum duration of cold stratification varies with species, with seeds of the same species from different provenances, and also with seeds of the same tree from different crop years (Wang 1976). Early research has proved that the longer the stratification period (up to a limit), the faster and more uniform will the seed germinate at lower temperatures of a wilder range (Allen 1967). It is important to determine the optimum period of cold stratification that favours increased germination rates for various tree species because we must know the critical range below and beyond which a diminishing or even detrimental effect will occur.

The optimum duration for stratifying seeds of Douglas-fir is 80-120 days for trees of both coastal and interior origin (Allen 1967), 112 days combining a minimum 28-day warm period and a maximum 84-day cold stratification for Eastern red cedar (Juniperus virginiana), 40-60 days for Eastern white pine of different provenances (Fowler and Dwight 1964), 42-56 days for Engelmann spruce (Picea engelmannii) and lodgepole pine (Pinus contorta) (Tanaka et al. 1986), 42-56 days for Northern provenances of red maple (Acer rubrum) (Wang and Haddon 1978), and others (Stockes 1965, Schopmeyer 1974).

Methods of Stratification

In general, there are two principal methods for cold stratifying seeds: under "naked" (without medium) conditions, and with a medium (or media). The first requires soaking seeds in tap water at room temperature for 24 h, draining water and surface-drying the seeds, and then placing them in vials, glass jars, plastic bags, or other containers for an appropriate period at 0 to 5°C. The second technique involves placing either dry or soaked seeds in alternate layers with a stratification medium such as sand, peat moss, vermiculite, or a mixture of them in a box, barrels, drums (or even outdoor pits) at 0 to 5°C for a specified period.

For prolonged cold stratification of large quantities of seeds, it is important to check temperature, moisture conditions and aeration frequently to achieve best results. When seeds are stratified with a medium or media, they can be placed in cotton bags or other porous material between layers of moist medium to facilitate separation of seeds from medium. It has been reported that moisture deficiencies in the medium during stratification will result in a discontinuous of adequate moisture supply to the seeds and this may nullify the stratification effect (Stokes 1965).

The advantage of using a medium (media) in cold stratification is that it not only provides a reservoir of moisture but may also prevent heating (Allen 1967). It appears that the intake of water by dormant seeds is not necessarily limited to the initial period of swelling but continues throughout the stratification period (Nikolaeva 1969).

A recently developed stratification technique known as "modified cold stratification" was found more effective in promoting germination rate than the standard method for some species (Tanaka et al. 1986). This technique involves a specified period of standard moist, cold stratification, followed by surface drying and dry-storing the stratified seeds. For example, Tanaka et al. (1986) recommended 42 to 56 days cold stratification followed by surface drying for nursery sowing of Engelmann spruce and lodgepole pine. Boyer et al. (1985) found that germination rate of loblolly pine seeds was greatly improved by "double stratification" in which the seeds were moist, cold stratified for 37 to 45 days, followed by drying and storing until the following year, and then restratification of the seeds for 30-35 days. For sugar maple (Acer saccharum), Janerette (1978) recommended stratifying seeds in aluminum foil pockets at 3°C to 4°C after a 24-hour soak in tap water.

Precautions for Handling and Storing Stratified Seed

To maintain maximum germinability of stratified seeds, it is important to handle them with care by storing the bulk of the seeds in cold or cool condition (1°C to 10°C). The required quantity should be taken out only for daily sowing. Warm environments tend to promote pre-germination before sowing, may dry out stratified seed, or may induce secondary dormancy. If sowing has to be delayed, the cold stratification period could be extended within the species limit. Otherwise, the seeds should be dried back to a lower moisture content for longer periods of storage, similar to storing leftover stratified seeds.

Procedures and conditions for handling and storing stratified seeds have been developed for Abies spp. (Edwards 1982), Douglas-fir (Allen 1967, Hedderwick 1968, Danielson and Tanaka 1978, Balcher 1982), ponderosa pine (Danielson and Tanaka 1978), loblolly pine (Barnett 1972, Belcher 1982), and slash pine (Belcher 1982).

Concluding Remarks

We are still unable to distinguish between cause and effect and to demonstrate with certainty a particular occurrence linking the chain of events leading to the induction and release of seed dormancy (Khan 1977). However, the unequivocally beneficial effects of stratification on the release of dormancy, and of enhancing the rate of germination, of uniformity and of total germination can be realized. In practice, it is essential to establish standard conditions and procedures in order to achieve consistent results of maximum germination.

More research is needed to find other basic information concerning critical and optimum periods for stratification of various eastern Canadian species, the effects of moisture and aeration on the duration and conditions of stratification, as well as to find an effective technique for storing stratified seeds.

Acknowledgment

I thank G. Scheer for helping with the illustrations, H. Frame, P. Gosling, G. Caron, and H.O. Schooley for generously providing their unpublished data, H.O. Schooley, R.K. Mittal, G. Murray for review, and A. Yapa for editing of the manuscript.

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Figure 1. Effect cold stratification on rate and total germination of monthly sown white spruce (A) and jack pine (B) seeds (Lines represent 12 monthly sowing times from April 1980 to March 1981). After Wang(1984)

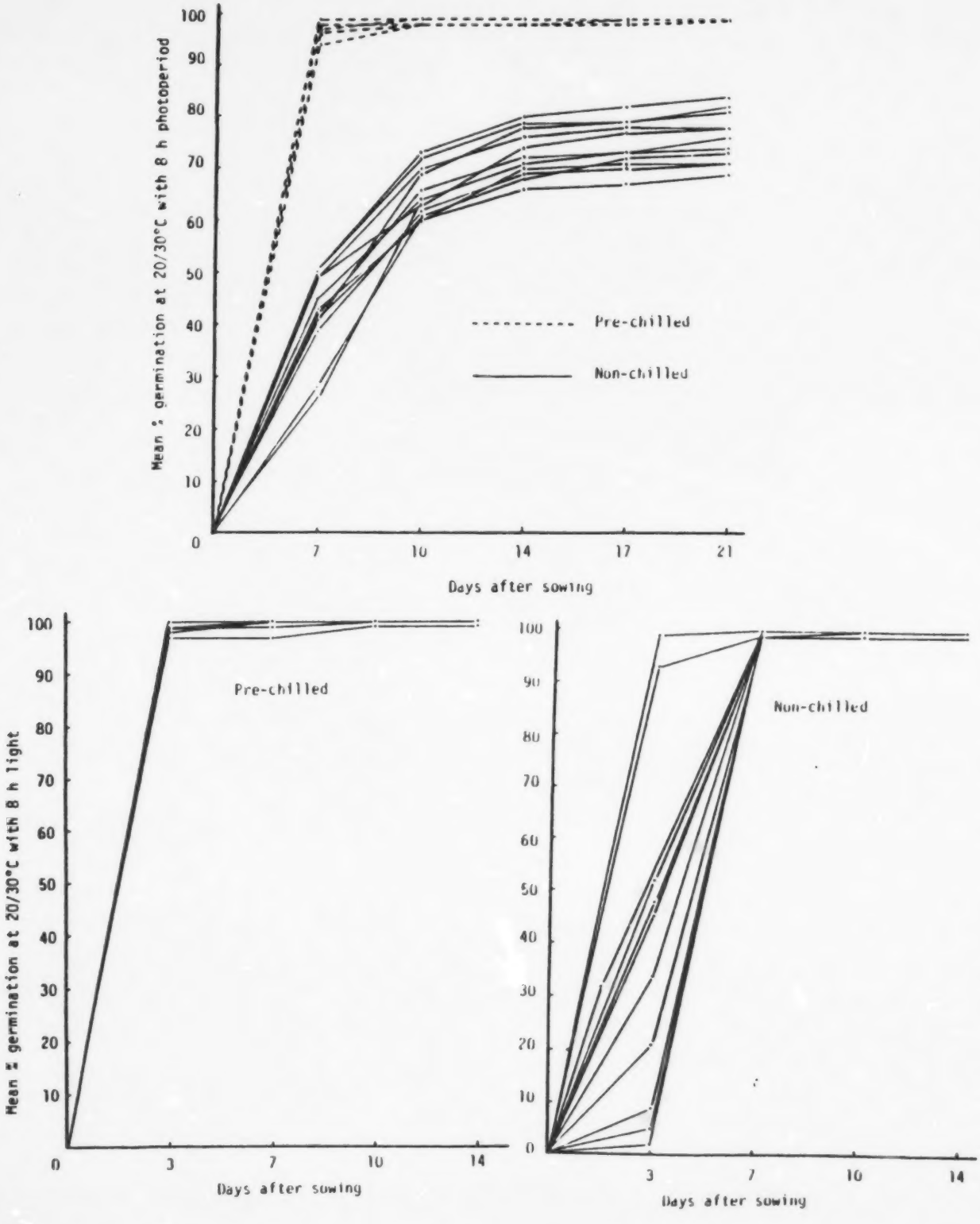


Figure 2. Effect of cold stratification on the rate of germination of monthly sown white spruce and jack pine seeds

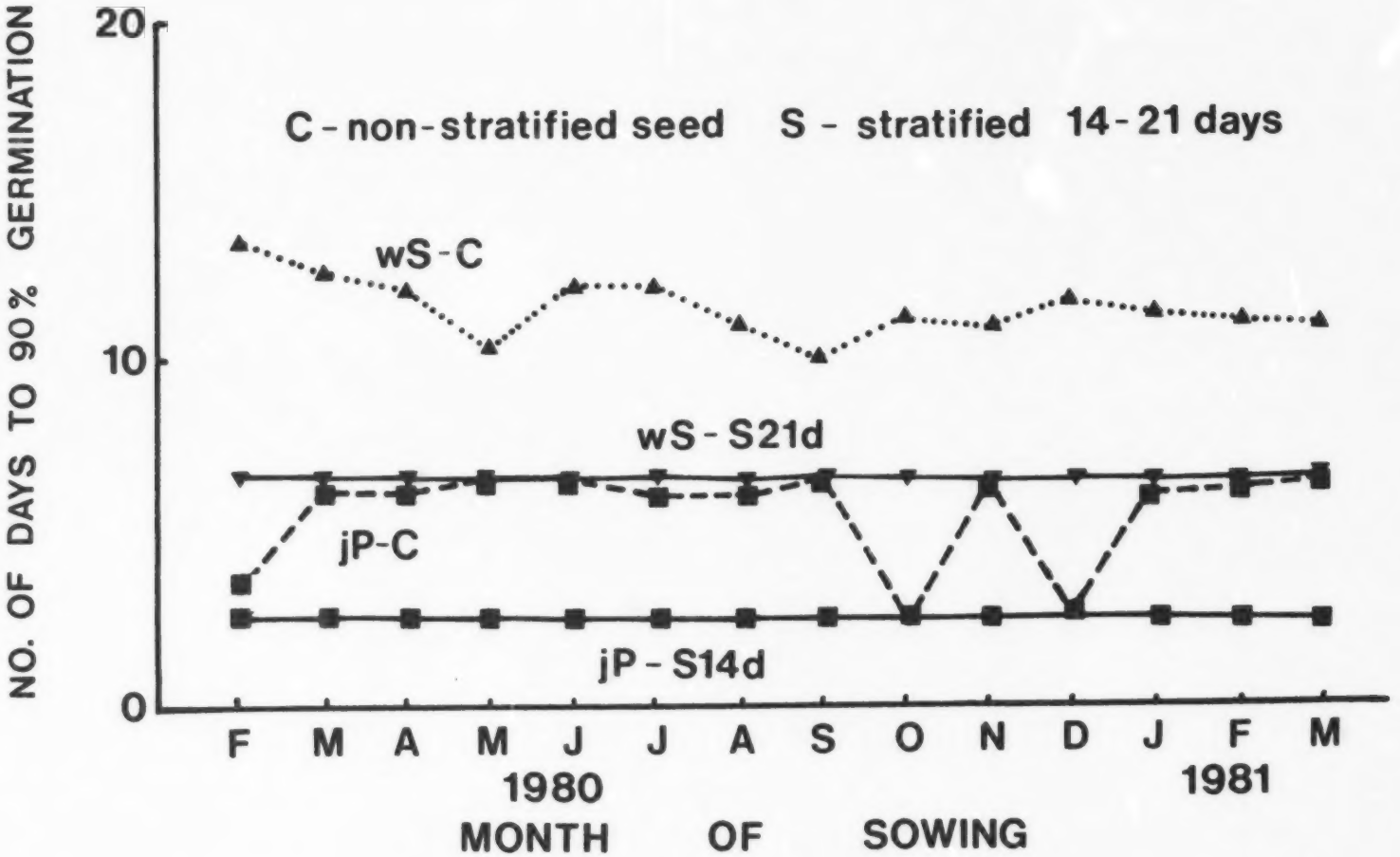


Figure 3. Effect of cold stratification on temperature requirement for germination of eastern white pine seeds.

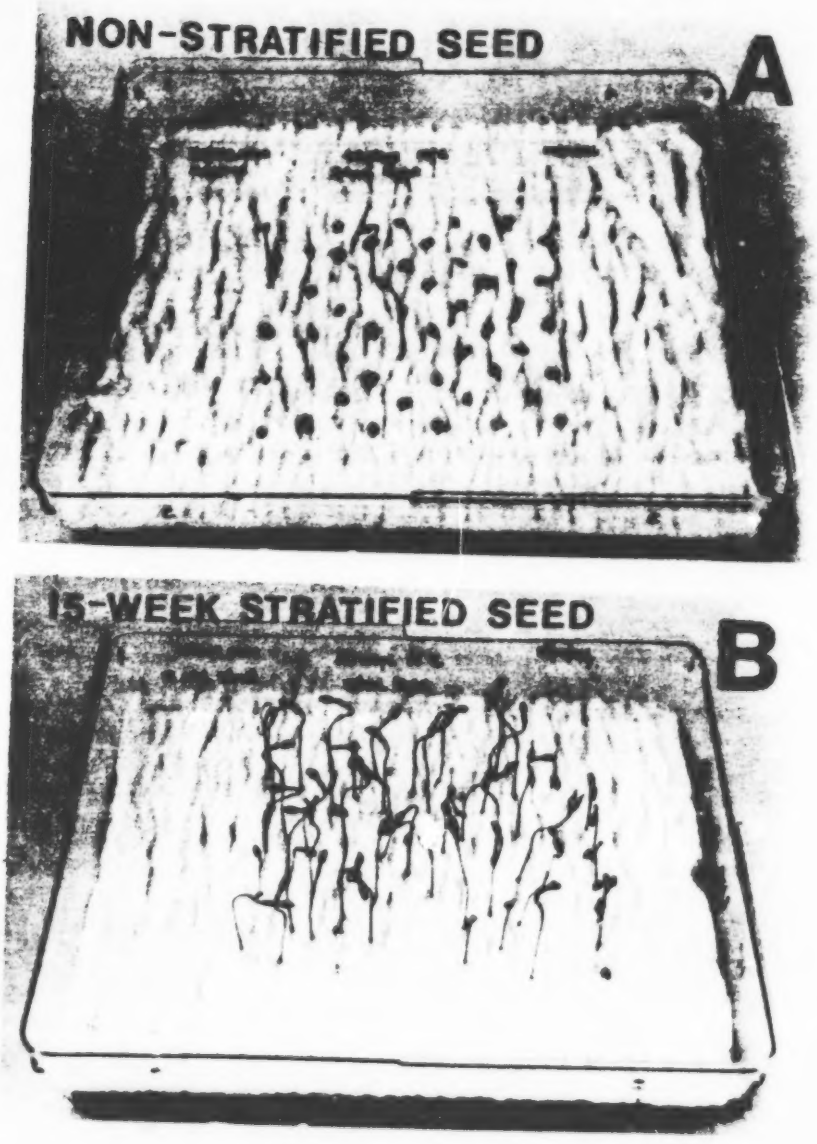


Figure 4. Effect of cold stratification on light requirement for germination of eastern white pine seeds.

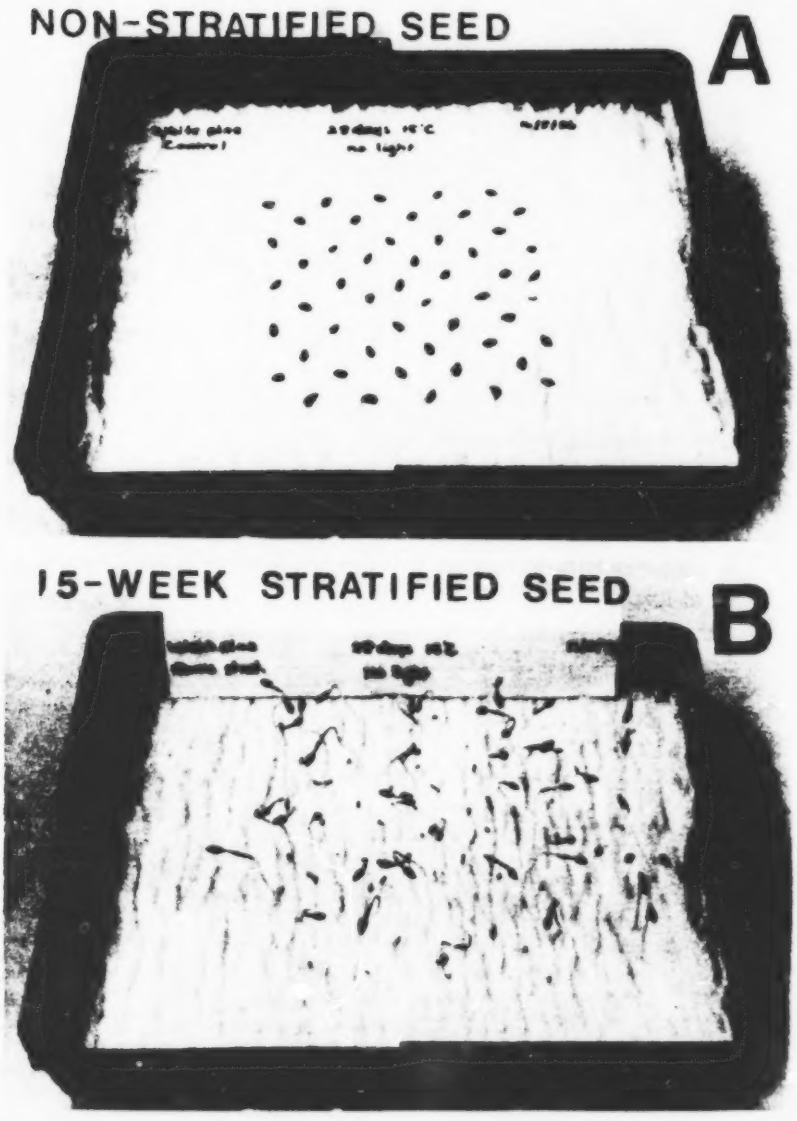
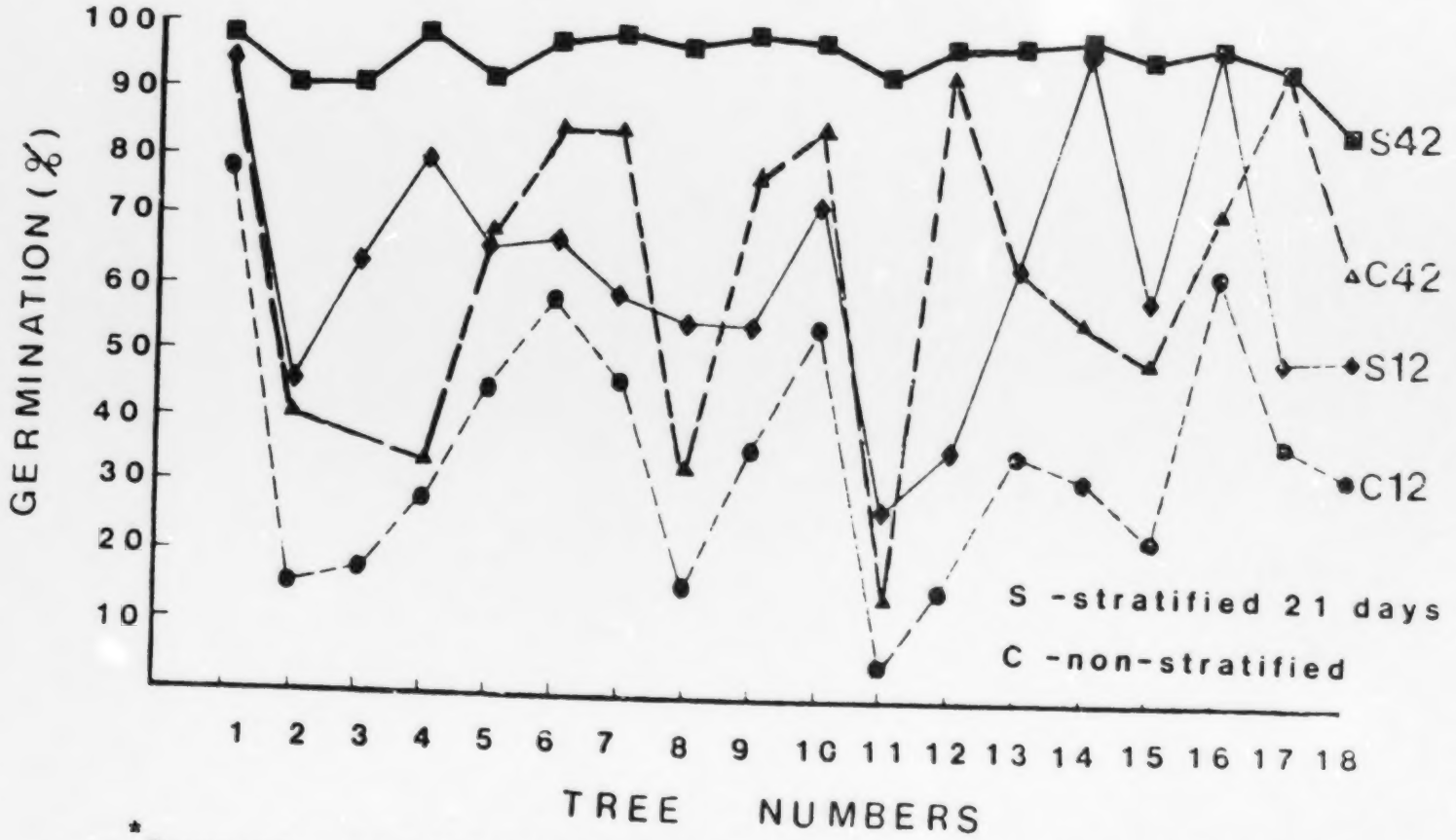
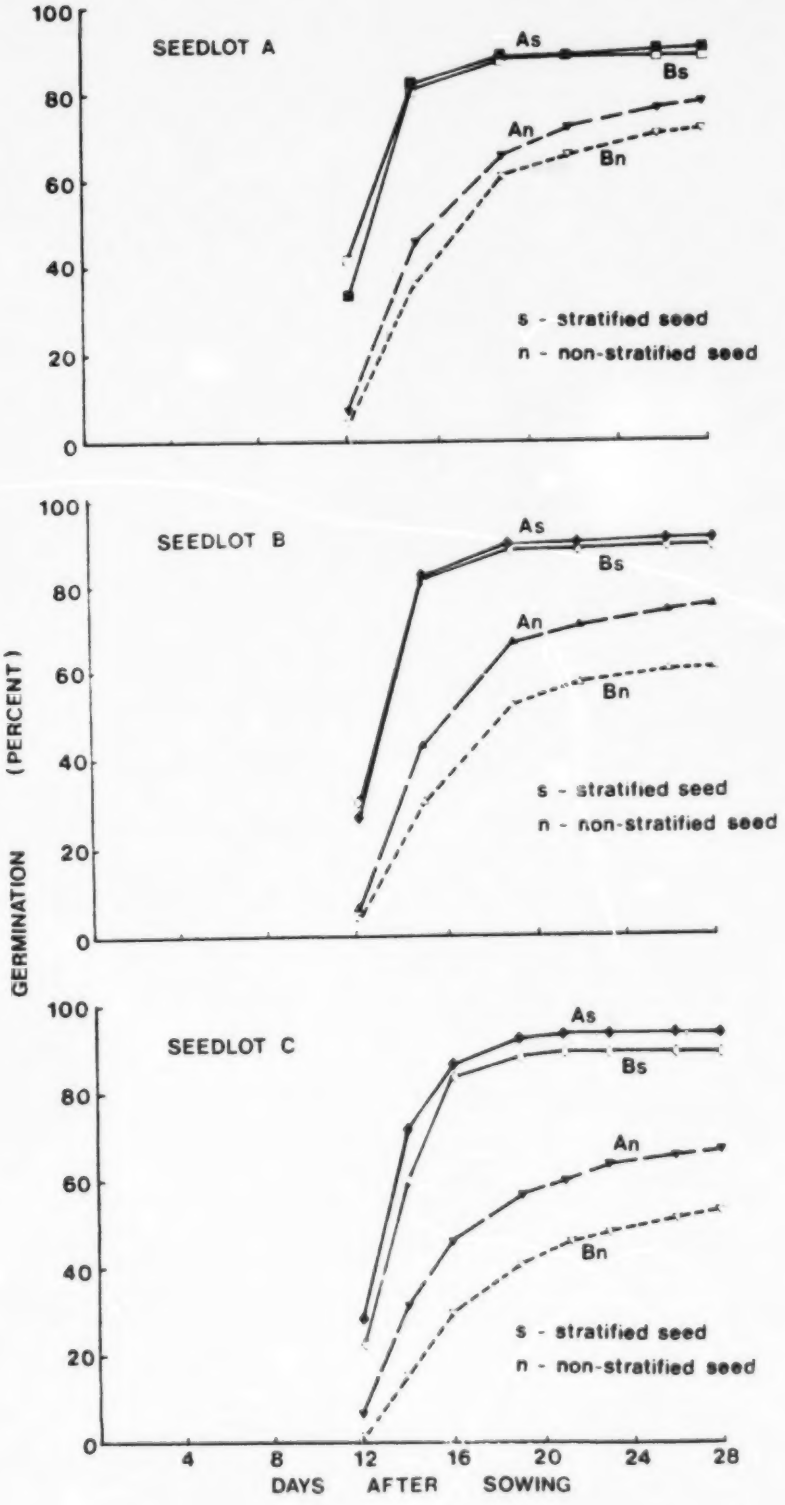


Figure 5 Effect of cold stratification on germination of white spruce seeds extracted from cones air-dried for different periods (12-23 and 42 days)*



*Courtesy unpublished data of G. Caron and H. O. Schooley 1984.

Fig. 6.1 Effect of cold stratification on germination of three white spruce seedlots extracted by two different seed extractories (A and B)



PERSONNEL UPDATE

Rodger M. Gordon
Manager
Personnel Policy Section
Human Resources Branch
Ministry of Natural Resources
Toronto, Ontario
M7A 1W3

Abstract

I intend to highlight a number of issues that are being dealt with in personnel that may well impact on your group. They are as follows:

1) Changes in the new working condition Collective Agreement

2) Problem areas with the "seasonal sections" of the Collective Agreement

3) Recent grievances which may impact on the administration of seasonal employees

4) Successor Rights Legislation - what is it? and how did we get involved?

I intend to talk to these broad subject areas and will be using overhead transparencies to illustrate a number of key points. I intend to keep my formal presentation as tight as possible as I anticipate these topics will generate a lot of questions and discussion.

ONTARIO'S OCCUPATIONAL HEALTH & SAFETY ACT

Claudia Tuzi
Supervisor
Occupation Health & Safety Section
Human Resources Branch
Ministry of Natural Resources
Toronto, Ontario

Abstract

An overview of the Ontario Health & Safety Act together with current proposed amendments will be presented. A question and answer period will allow for the clarification of particular concerns.

BRAGG & BOAST SESSION - JUNE 17

SPEAKER	TOPIC	LOCATION
Nancy Chong	Lophodermium Field Status	Pest Control Section, Maple
Vic Timmer	Exponential Fertilization with B/R, C/S	Glendon Hall Lab.
Rodger Street	Tree Improvement Breeding and Orchard Irrigation	Environment Canada Atmospheric Environment, Toronto
Ron Sherwin	Emergency Stock Storage	Thunder Bay Nursery
Mayda Palcic	Fertilizer Trials	Thunder Bay Nursery
Doug MacMillan	Top Dressing Trials -Finnish Solution	Swastika Nursery
Bernie Phillion	Conditioning C/S to Overwinter	Thunder Bay Nursery
Jim Atkinson	Pineland's Programs	Hadishville Nursery, Manitoba
Ernie Townsend	Nursery Safety System	St. Williams Nursery
Brian Whelan	C/S Crop System	Thessalon Nursery
Bill Bunting	Foliar Analysis - Help or Hindrance	Nu-Tech Services

Note: 1. Only Bill Bunting submitted written report, see page 79.

2. All other speakers made verbal presentations.

FOLIAR ANALYSIS

AID OR

HINDRANCE

W.R. Bunting
Nu-Tech Services
Box 424
Orono, Ontario
LOB 1MO

and

J.D. Carleton
Superintendent
Chapleau Nursery
190 Cherry Street
Chapleau, Ontario
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Introduction

The trial which resulted in this paper was designed at Chapleau, during the tour Tony Citro and I had around the province, in the spring of 1986. This was done at the request of John Carleton, in response to the question "do you know if phosphorus is limiting growth on your nursery? The trial is subsequently established at Gogama, hence the Gogama name in Figure 1.

The trial consists of five treatments and four replications, and was designed to take a "quick look" to see if phosphorus was limiting growth at Chapleau. The following treatments were included in the trial (Figure 1).

1. ØN - No nitrogen or phosphorus - Control.
2. N - Normal nitrogen - supplied from Ammonium Nitrate, the normal nitrogen fertilizer used at Chapleau.
3. .5NP* - Half the normal nitrogen plus phosphorus. Enough Mono Ammonium Phosphate (MAP) was used to supply the half rate of nitrogen.
4. NP* - Normal nitrogen plus phosphorus. Once again enough MAP was used to supply the normal rate of nitrogen.
5. 2NP* - Twice normal nitrogen plus phosphorus applied as MAP.

*NB - Each 100 kg/ha MAP applied supplies 23 kg/ka of elemental phosphorus.

The trial was conducted in Compartment 6, in rising 1+0 Jack Pine. The seedlings were growing at an average density of 243.26/m² (22.6/ft²). The phosphorus level in the compartment was 22.4 mg/100g, a respectable level, but below the normally recommended level of 30 mg/100g.

Results

Two sets of samples were taken at the end of the season. The first set was processed at Chapleau where determinations for Height, Root Collar Diameter, Top and Root Dry Weight and Root Area Index were made (Table 1). The second set was sent to Prof. Vic Timmer at Glendon Hall where determinations were made for Height, Root Collar Diameter, Total Dry Weight, Root Area Index and Nutrient Concentrations (percent) for Nitrogen, Phosphorus, Potassium, Magnesium and Calcium (Table 2).

1. Morphological measurements

There were very highly significant differences within the treatments (Tables 1 & 2). In general the ØN treatment was the smallest, the N and .5NP treatments produced trees about the same size (even though the latter supplied only half the Normal nitrogen), and the NP and 2NP treatments produced trees significantly larger than the rest.

Comparing the N and 2N treatments for:

Ht. the 2N was 39.5% larger
RCD the 2N was 32.3% larger
RAI the 2N was 38.8% larger
TDW the 2N was 73.3% larger

From these results (Table 1 & 2, & Figure 2) we think it is safe to say that Phosphorus level of 22mg/100g in Compartment 6 was limiting growth of the seedling trees.

2. Nutrient Concentrations

In looking at the nutrient concentration percent of Nitrogen and Phosphorus (Table 2) the results are variable. The N treatment has a concentration almost as large as the 2NP treatment while the NP treatment is about the same as the ØN treatment and the .5NP treatment has the lowest concentration of nitrogen of the five. When the results are plotted (Figure 3) nitrogen does show a slight trend to increase with increasing additions of fertilizer. Phosphorus on the other hand is almost a complete reversal with the ØN and N treatments having the highest concentrations, while the phosphorus treatments (.5NP, NP & 2NP) had significantly lower concentrations. The trend line here indicates a decrease in phosphorus concentrations with increasing additions of phosphorus.

3. Nutrient Uptake

The above paradoxical situation was solved when Dr. Timmer suggested we look at nutrient uptake, which is the nutrient concentration percent multiplied by the Total dry weight of the seedling. When this was done (Table 2 & Figure 4) a semblance of order was restored. Increasing levels of both nitrogen and phosphorus resulted in increasing (although not always significant) levels of the nutrient being taken up.

This then solves an old problem for us, We had never been able to make sense out of the foliar analysis tests We have had performed over the years, since, quite often the foliage nutrient concentration percent of the unhealthy seedling had higher nutrient concentrations than did the healthy seedling. We see that here in phosphorus, where the ØN treatment has the highest concentration (significantly so) of any of the phosphorus treatments. While in the uptake calculation the ØN has the smallest amount of phosphorus (significantly so) of any of the other phosphorus treatments. This effect is commonly known as the "dilution effect". In the treatments containing increasing levels of phosphorus more phosphorus was taken up and utilized by the tree, but since the resulting seedling was larger the phosphorus percent content was diluted and showed up as a smaller percent content.

Figure 5 helps to depict the differences between concentration and uptake.

4. Growth Curves

Growth curves resulting from the additions of phosphorus and nitrogen indicate that they are highly correlated. Increasing additions of nitrogen and phosphorus result in increasing seedling sizes (Figure 6). The MAP (13-52-0) additions seem to produce more growth than does the Ammonium Nitrate additions. This is most likely the result of the synergistic effect of adding nitrogen and phosphorus together when phosphorus is limiting growth. Neither one of these curves indicate at the levels used, that either phosphorus or nitrogen has placed the growth on the backside of the curve.

Discussion

It always appealed to us, as nurserymen, to sample healthy and problem seedlings and to try to determine any nutrient deficiency problem through foliar analysis. After this trial we feel and must ask the question "why bother?" Foliar analysis of nutrient content (percent) also won't give you the answer. It may even lead you astray as far as estimations of desired nutrient levels are concerned.

We can't help but wonder if the way to go is not with the nutrient content of the seedling stated in mg of nutrient per seedling. Would it, for instance, be possible to develop standard nutrient curves, similar to Figure 7, with the TDW of the seedling plotted over mg of nutrient per seedling. This could be done for both macro and micro nutrients. Comparing actual nutrient content per seedling against this standard curve might give the nurseryman a tool to assess nutritional problems.

We would urge any of you who don't know if phosphorus is limiting (regardless of your soil phosphorus levels, be it 15 or 30 mg/100g) to try top dressing with Mono Ammonium Phosphate (MAP) to see if you can increase your seedling growth. You don't have to lay out a formal trial if you don't feel like it (although this is best). Do part of a compartment with MAP and the rest with your normal top dressing treatment, then compare results at the end of the year. When making comparisons between treatments you should make sure that the two areas being sampled have the same seedling density.

Table 1

SUMMARY
CHAPLEAU NITROGEN
& PHOSPHORUS TRIAL

1986

Treatment	Ht. cm	RCD mm	RAI cm²	TDW g	T/R
0n	5.07a	0.97a	6.07a	.38a	2.13
N	7.78b	1.64b	12.04b	.91b	2.38
.5n+P	8.42c	1.80bc	10.64b	.97b	2.71
N+P	9.56d	1.94 c	12.06b	1.16c	2.80
2N+P	10.85e	2.17 d	16.71c	1.58d	2.60
	***	***	***	***	NS

NS - No significant differences.
*** - Significant differences at the 0.1% level.
Figures followed by the same letter do not vary significantly at the 5% level.

Table 2

SUMMARY
NITROGEN AND PHOSPHORUS TRIAL
1+0 JACK PINE
CHAPLEAU NURSERY
1986

Samples Taken for
Foliar Analysis

Physical Properties

Treatment	RCD mm	TDW g	RAI cm^2	HT cm
0N	1.28a	0.40a	10.05a	5.48a
N	1.83 b	0.70 b	12.95a	6.75 b
.5N+P	1.93 bc	0.89 b	12.58a	9.00 c
N+P	2.22 c	1.17 c	17.58 b	10.35 d
2N+P	2.68 d	1.52 d	16.67 b	11.50 e
	***	***	**	***

Nutrient Concentrations (Percent).

Treatment	Nitrogen	Phosphorus	Potassium	Magnesium
0N	1.57 b	0.28a	1.25a	0.09
N	2.20a	0.25ab	1.23 b	0.09
.5N+P	1.51 b	0.21 c	1.00 c	0.08
N+P	1.67 b	0.22 bc	1.06 c	0.09
2N+P	2.31a	0.24 bc	1.07 c	0.10
	***	**	**	NS

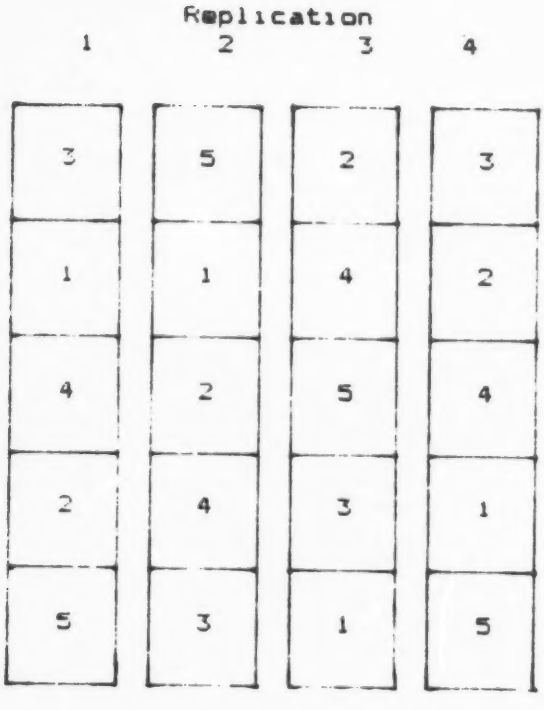
Nutrient Uptake
(Nutrient % x TDW)

Treatment	Nitrogen	Phosphorus	Potassium	Magnesium
0N	0.66a	0.11a	0.51a	0.04a
N	1.542bc	0.18 b	0.85 b	0.06ab
.5N+P	1.33 b	0.19 b	0.87 b	0.07 b
N+P	1.97 c	0.26 c	1.23 c	0.11 c
2N+P	3.53 d	0.37 d	1.62 d	0.15 d
	***	***	***	***

NS - No significant differences.
** - Significant differences at the 1% level.
*** - Significant differences at the .1% level.
Figures followed by the same letter do not vary significantly at the 5% level.

Figure 1

FERTILITY TRIAL No. 1
PHOSPHORUS AND NITROGEN
GOGAMA NURSERY
1987



Treatments

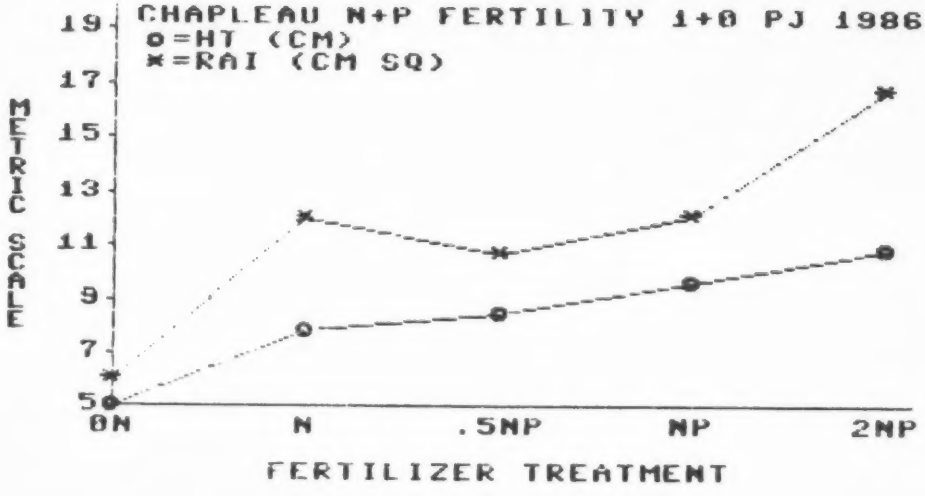
1. ØN - No nitrogen of phosphorus - Control.
2. N - Normal nitrogen - supplied from Ammonium Nitrate (NH_4NO_3).
3. .5 N + .5 P - Half normal nitrogen and half normal phosporus rate - supplied from Mono Ammonium Phosphate (MAP).
4. N + P - Normal nitrogen and normal phosphorus rate - supplied from MAP.
5. 2N + 2P - Twice normal nitrogen and twice normal phosphorus rate - supplied from MAP.

Plot Size - 3m x 1.12m (width of bed).

Amount of Fertilizer per Plot

Treatment 2 - N - Normal nitrogen - 20g per plot - Ammonium Nitrate.
Treatment 3 - .5N+.5P - half Normal Nitrogen + P - 26g Mono Ammonium Phosphate (MAP).
Treatment 4 - N + P - Normal Nitrogen + P - 52g MAP.
Treatment 5 - 2N + 2P - Twice Normal Nitrogen + P - 104g MAP.

Figure 2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o=HT (CM)
*=RAI (CM SQ)
METRIC SCALE
19
17
15
13
11
9
7
5
0N
N
.5NP
NP
2NP
FERTILIZER TREATMENT

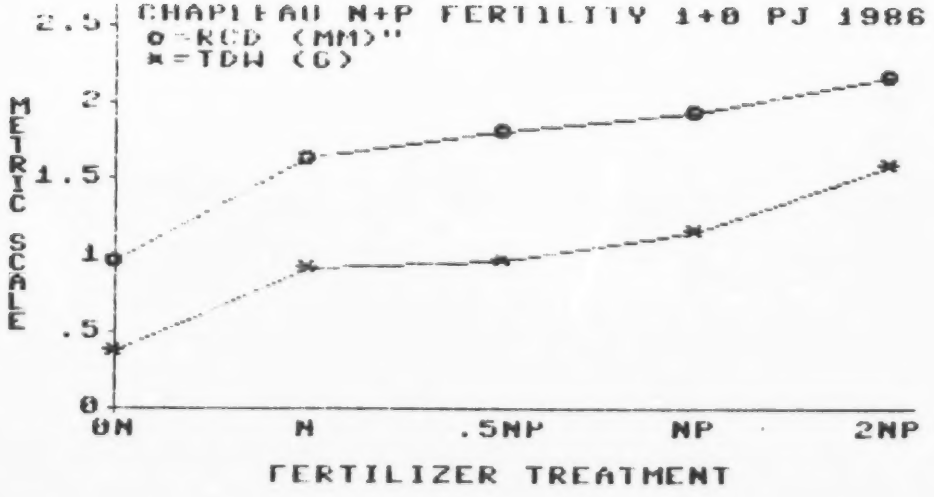
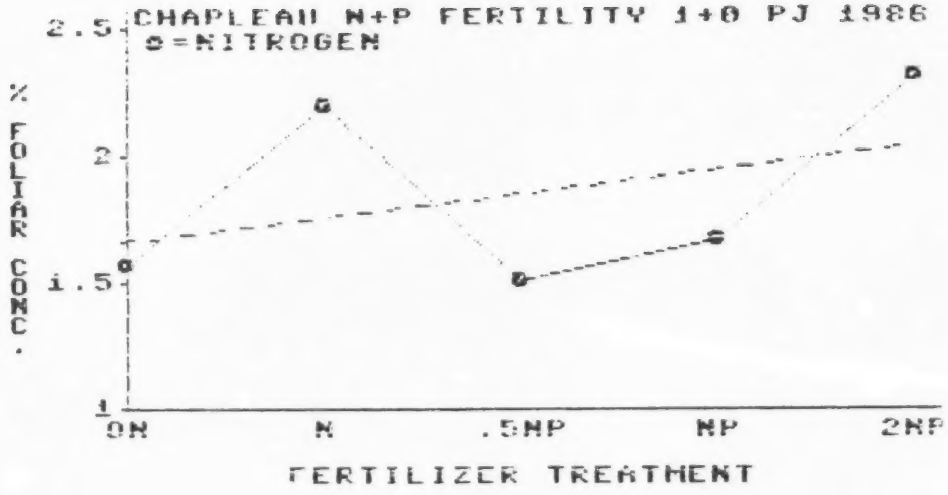

CHAPLEAU N+P FERTILITY 1+0 PJ 1986
o=RCD (MM)"
*=TDW (G)
METRIC SCALE
2.5
2
1.5
1
.5
0
0N
N
.5NP
NP
2NP
FERTILIZER TREATMENT

Figure 3


CHAPLEAU N+P FERTILITY 1+0 PJ 1986
⊖=NITROGEN
% FOLIAR CONC.
2.5
2
1.5
1
0N
N
.5NP
NP
2NP
FERTILIZER TREATMENT

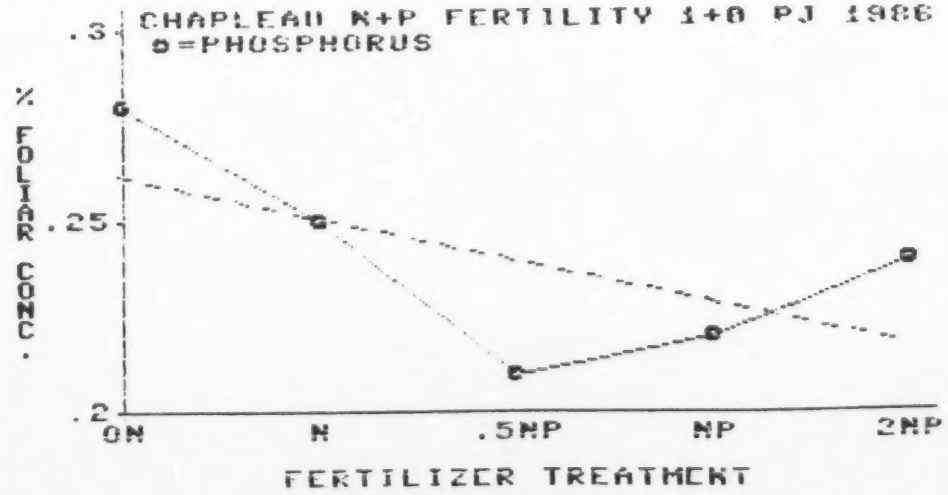
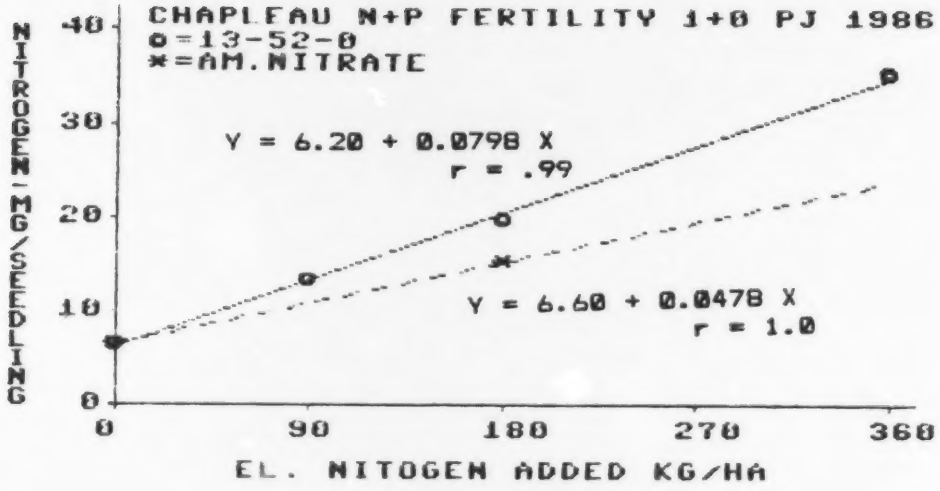

CHAPLEAU N+P FERTILITY 1+0 PJ 1986
⊖=PHOSPHORUS
% FOLIAR CONC.
.3
.25
.2
0N
N
.5NP
NP
2NP
FERTILIZER TREATMENT

Figure 4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Y = 6.20 + 0.0798 X
r = .99
Y = 6.60 + 0.0478 X
r = 1.0
NITROGEN MG\SEEDLING
40
30
20
10
0
0
90
180
270
360
EL. NITOGEN ADDED KG/HA

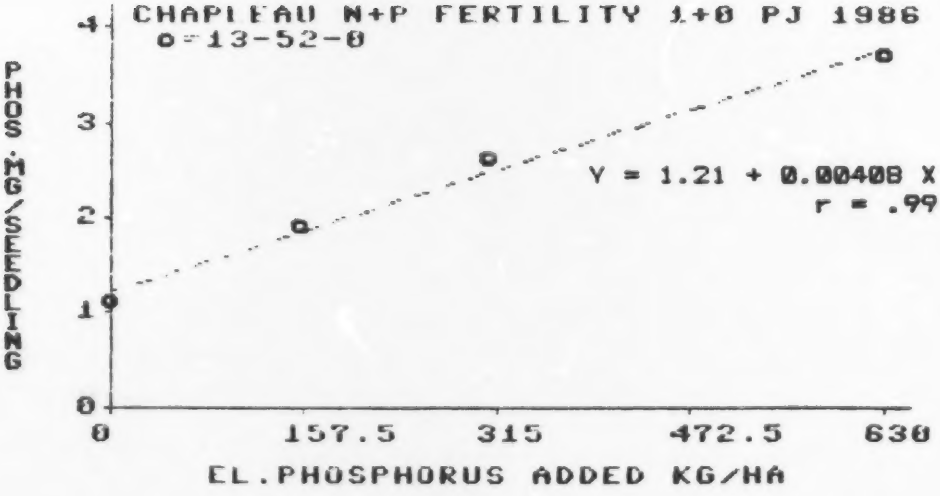
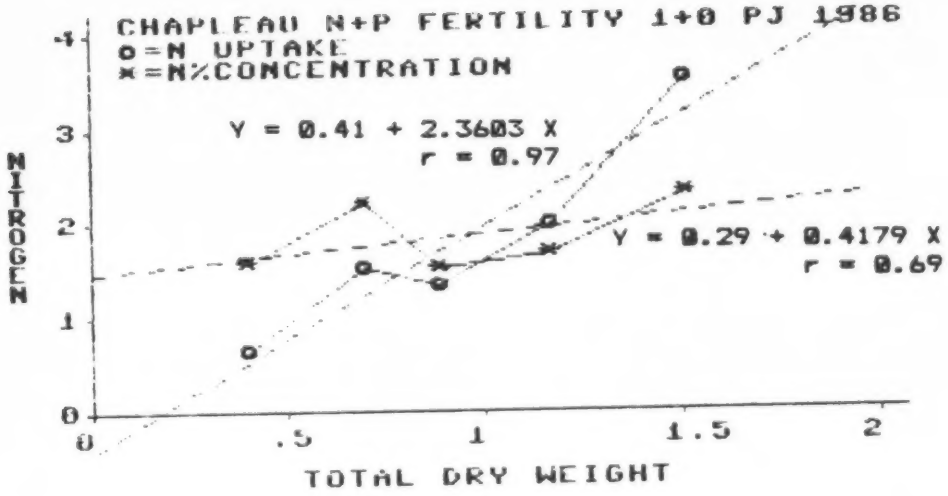

CHAPLEAU N+P FERTILITY 1+0 PJ 1986
o=13-52-0
Y = 1.21 + 0.00408 X
r = .99
PHOS MG\SEEDLING
4
3
2
1
0
0
157.5
315
472.5
630
EL.PHOSPHORUS ADDED KG/HA

Figure 5


CHAPLEAU N+P FERTILITY 1+0 PJ 1986
o=N UPTAKE
x=N%CONCENTRATION
Y = 0.41 + 2.3603 X
r = 0.97
Y = 0.29 + 0.4179 X
r = 0.69
NITROGEN
4
3
2
1
0
0
.5
1
1.5
2
TOTAL DRY WEIGHT

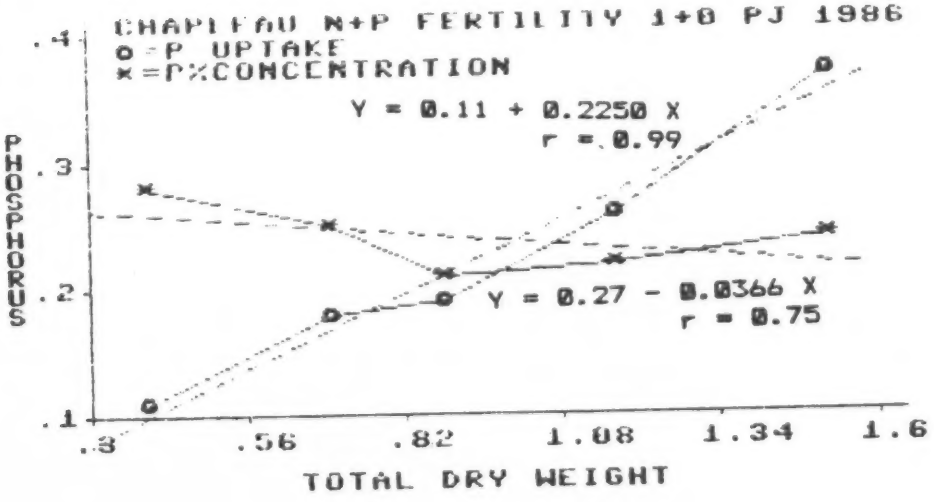
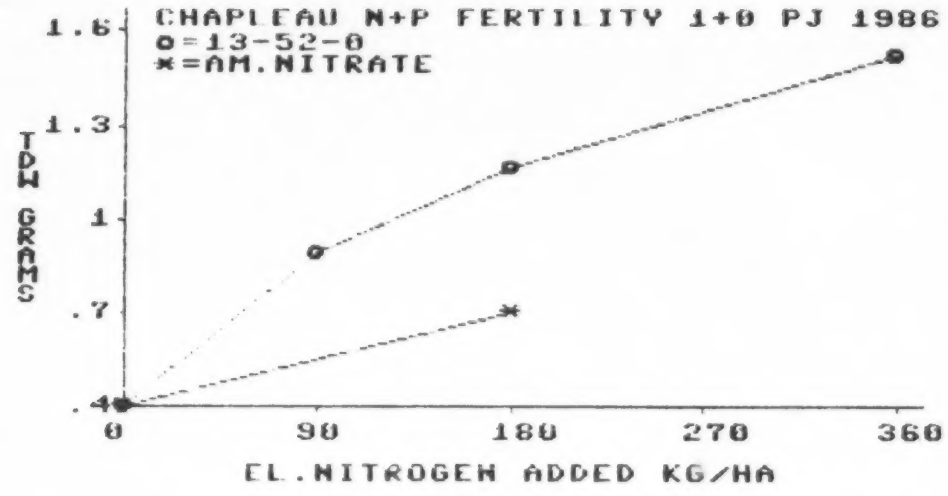

CHAPLEAU N+P FERTILITY 1+0 PJ 1986
o=P UPTAKE
x=P%CONCENTRATION
Y = 0.11 + 0.2250 X
r = 0.99
Y = 0.27 - 0.0366 X
r = 0.75
PHOSPHORUS
.4
.3
.2
.1
.3
.56
.82
1.08
1.34
1.6
TOTAL DRY WEIGHT

Figure 6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TDW GRAMS
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1.3
1
.7
.4
0
90
180
270
360
EL.NITROGEN ADDED KG/HA

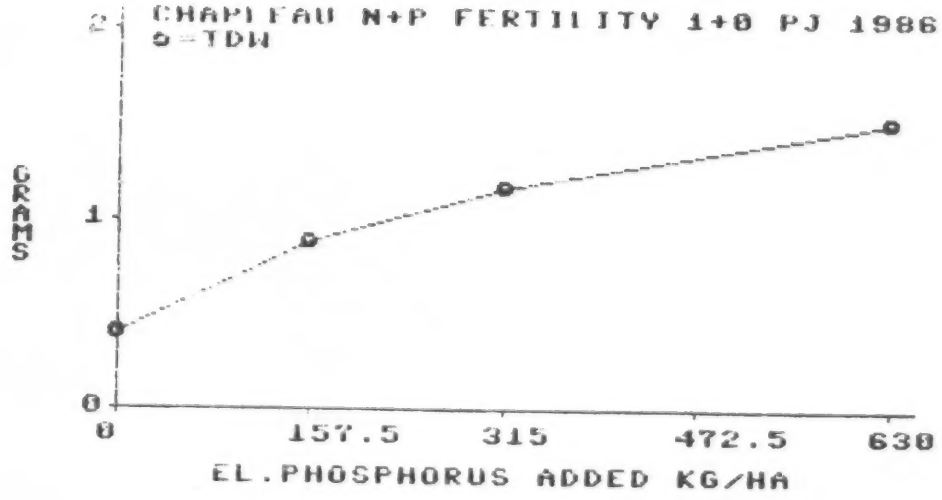
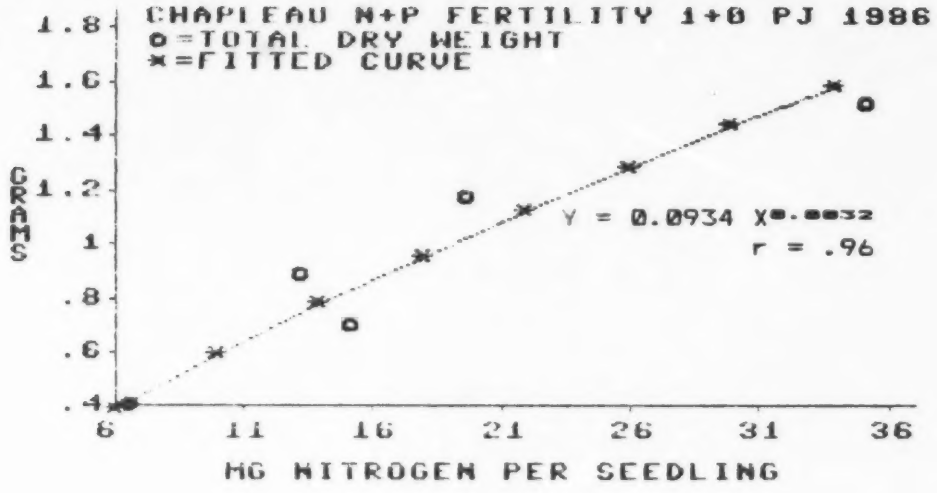

CHAPLEAU N+P FERTILITY 1+0 PJ 1986
o=TDW
GRAMS
2
1
0
0
157.5
315
472.5
630
EL.PHOSPHORUS ADDED KG/HA

Figure 7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r = .96
GRAMS
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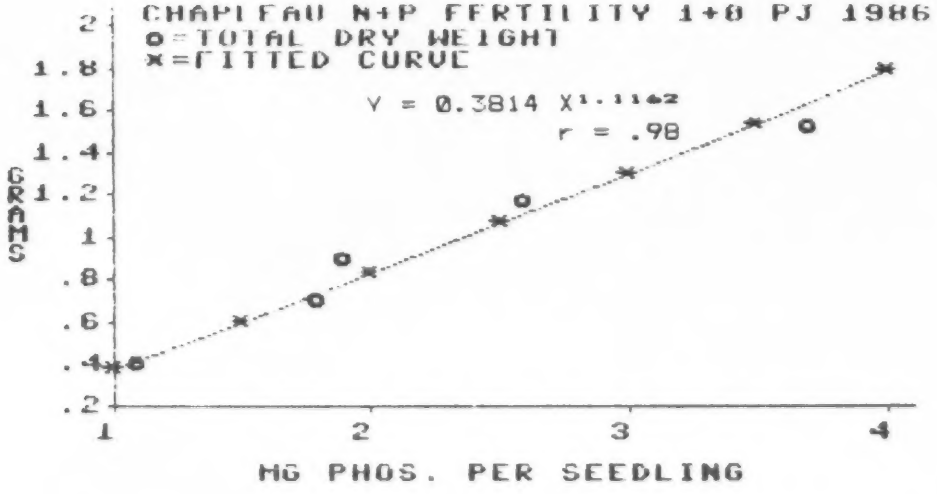
1.6
1.4
1.2
1
.8
.6
.4
6
11
16
21
26
31
36
MG NITROGEN PER SEEDLING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o=TOTAL DRY WEIGHT
*=FITTED CURVE
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r = .98
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1.6
1.4
1.2
1
.8
.6
.4
.2
1
2
3
4
MG PHOS. PER SEEDLING

Appendix 1

AGENDA

Monday, June 15, 1987

19:00-21:00 Registration and Ice Breaker (Cash Bar), Bestwestern Motor Inn - Sunset Room.

Tuesday, June 16

08:00-08:30 Registration Continues in Sunset Room

08:15 Opening Remarks
G.M. Tupling, Dryden District Manager
J.M. McIntyre, Dryden Nursery Superintendent

08:30 Land Preparation ..... Neil Moore

10:00 Coffee

10:30 Status and Control of Cylindrocladium Root Rot in Ontario Provincial Forest Nurseries...Jennifer Juzwick

11:15 Fumigation: The Nursery Experience ..... Fredrick Zensen

12:00 Lunch

13:15 Undercutting and Root Wrenching in Ontario, Where Are We Going? ..... Gerry Racey

14:15 Windbreaks and Crop Protection ..... Charles Baldwin

15:00 Coffee

15:15 Greenhouse Transplant System Development.....Terry Myland

15:40 Greenhouse Transplant Program ..... Peter Schuessler

16:05 Techniculture Transplants ..... Bob Klapprat

19:30 Banquet, Riverview Lodge ..... "Mystery Speaker"

Wednesday, June 17

08:30	Depart from Bestwestern Motor Inn	
09:00	Field Tour Dryden Tree Nursery	Nursery staff
12:00	Lunch	
13:00	Field Tour Dryden Tree Nursery	Nursery staff
16:30	Depart Nursery for Dryden	
19:30	Bragg and Boast Session, White Otter Room, see separate Agenda	Page 78

Thursday, June 18

08:00	The Beneficial Effect of Stratification on Tree Seed Germination	Ben Wang
09:00	Personnel Update (Abstract Only)	Rodger Gordon
10:00	Coffee	
10:30	Ontario's Occupational Health and Safety Act (Abstract Only)	Claudia Tuzi
12:00	Lunch	
13:00	Tours: 1) Great Lakes Forest Products Complex 2) Private Growers 3) Northwestern Fire Management Centre	
16:15	Depart for Airport	

Friday, June 19 (Optional)

07:30	Depart Bestwestern Motor Inn for Tree Improvement and Silviculture in the Northwestern Region: Post Conference Tour
16:00	Return to Dryden
16:15	Arrive Dryden Airport

Appendix 2

REGISTERED DELEGATES AS OF 87.06.12

ATKINSON, JIM BOX 45 HADASHVILLE MANITOBA ROE 0X0 (204)426-5235	Hadashville Nursery, Manitoba
BALDWIN, CHARLES MAIN STREET EAST RIDGETOWN ONTARIO NOP 2C0 (519)674-5456	Ontario Ministry of Agriculture and Food
BOUFFORD, DON BOX 119 ORONO ONTARIO LOB 1M0 (416)938-9147	MNR - Orono Tree Nursery
BUNTING, BILL P.O.BOX 424 ORONO ONTARIO LOB 1M0 (416)983-5214	Nu-Tech Services
BURNS, RENDY BOX 90 WABIGOON ONTARIO POV 2W0 (807)938-6326	MNR - Dryden Tree Nursery
BURNSIDE, NORMA BOX 310 THESSALON ONTARIO POR 1L0 (705) 842-3634	MNR - Thessalon Tree Nursery
CAMERON, RICHARD BOX 45 HADASHVILLE MANITOBA ROE 0X0 (204) 426-5235	Hadashville Nursery, Manitoba
CAMPBELL, MARK BOX 90 WABIGOON ONTARIO POV 2W0 (807) 938-6326	MNR - Dryden Tree Nursery

CAMPBELL, ALF
RR#4
KEMPTVILLE
ONTARIO KOG 1JO
(613)258-8355

MNR - C. Howard Ferguson Tree Nursery

CARLETON, JOHN
190 CHERRY ST.
CHAPLEAU
ONTARIO POM 1KO
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MNR - Chapleau Tree Nursery

CASELLA, TERRY
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MNR - Northern Forest Research

CITRO, TONY
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TORONTO
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M7A 1W3
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MNR - Stock Production Unit

COLOMBO, STEVE
RR#2
MAPLE
ONTARIO
LOJ 1EO
(416) 832-2761

MNR - OTIFBI

CREASEY, KIM
BOX 70
ANGUS
ONTARIO
LOM 1BO
(705)424-5311

MNR - Ontario Tree Seed Plant

D'ARCY, HEATHER
OLIVER ROAD
THUNDER BAY
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Lakehead University, Thunder Bay

DAVIES, CARY
RR#1
THUNDER BAY
ONTARIO
P7C 4T9
(807) 939-2561(30)

MNR - Thunder Bay Tree Nursery

DAWES, ROBIN
48 PRINCESS STREET
DRYDEN
ONTARIO
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(807)-937-5239

Evergreen Farms

DAY, R.J.
OLIVER ROAD
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DOYLE, PATRICK
VAN BUREN STREET
KEMPTVILLE
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KOG 1JO
(613)258-8352

MNR - Eastern Reg. Systems

ENG, KENNETH
10670 YONGE STREET
RICHMOND HILL ONTARIO
L4C 3C9
(416)883-3251

MNR - Central Region

FILION, ROSAIRE
P.O.BOX 150
MOONBEAM
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OLIVER ROAD
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Lakehead University, Thunder Bay

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RR#1
NOLALU
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MNR - Chapleau Tree Nursery

GLERUM, CHRIS
RR#2
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LOJ 1EO
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MNR - OTIFBI

GORDON, RODGER
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M7A 1W3
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MNR - Admin. Services

HICKS, GORDON
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EAR FALLS
ONTARIO
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Wellair Concepts Inc.

HODGSON, TREVOR
12150 160 ST.
EDMONTON
ALBERTA
T5V 1H5
(403)453-5961

Beaver Plastics Ltd.

HUISMAN, TJERK
BOX 129
GOGAMA
ONTARIO
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MNR - Gogama Tree Nursery

JARVIS, SCOTT
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MNR - Thunder Bay Tree Nursery

LICK, DAVID
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DRYDEN
ONTARIO
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(807)937-6621

Tamarac Nurseries

LUCAS, SYD
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MNR - Thessalon Tree Nursery

MANSFIELD, CARL
MIDHURST
ONTARIO
LOL 1XO
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MNR - Midhurst Tree Nursery

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ONTARIO
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MOORE, NEIL
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LINDSAY
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OMAF - Soil Conservation Advisor

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MNR - Midhurst Tree Nursery

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